Mendota Pool Bypass and Reach 2B Improvements Project

Programmatic Biological Assessment for the National Marine Fisheries Service

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2016

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List of Abbreviations and Acronyms

BA	biological assessment
BMP	best management practice
BO	biological opinion
°C	degrees Celsius
cfs	cubic feet per second
CL	critical low (water year)
CNDDB	California Natural Diversity Database
Corps	U.S. Army Corps of Engineers
dB	decibel
DFW	California Department of Fish and Wildlife
DO	dissolved oxygen
DPS	Distinct Population Segment
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
Exchange Contractors	San Joaquin River Exchange Contractors
°F	degrees Fahrenheit
FE	Federally Endangered
FHWG	Fisheries Hydroacoustic Working Group
FMP	Fishery Management Plan
FT	Federally Threatened
GIS	Geographic Information System
HAPC	Habitat Area of Particular Concern
µPa	microPascal
MP	mile post
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
ND	normal dry (water year)
NEP	nonessential experimental population
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
NW	normal wet (water year)
PEIS/R	Program Environmental Impact Statement/ Environmental Impact Report
PIT	passive integrated transponder

Project	Mendota Pool Bypass and Reach 2B Improvements Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RM	River Mile
SCADA	supervisory control and data acquisition
SEL	sound exposure level
Settlement	Stipulation of Settlement in NRDC, et al., v. Kirk Rodgers, et al.
Settling Parties	Natural Resources Defense Council, Friant Water Authority, and the U.S. Departments of the Interior and Commerce
SJRRP	San Joaquin River Restoration Program
USFWS	U.S. Fish and Wildlife Service
W	wet (water year)

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1.0 Introduction

After more than 18 years of litigation (*Natural Resources Defense Council (NRDC), et al., v. Kirk Rodgers, et al.*), the Settling Parties, including NRDC, Friant Water Authority, and the U.S. Departments of the Interior and Commerce agreed on the terms and conditions of the San Joaquin River Settlement (Settlement), which was subsequently approved by the U.S. Eastern District Court of California in 2006. The San Joaquin River Restoration Program (SJRRP) is a direct result of the Settlement, which stipulated flow release magnitude, timing, and duration (i.e., hydrographs) from Friant Dam under different water-year types, among other things.

The SJRRP was established to implement the Settlement through a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River, and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from Interim and Restoration flows. The anticipated benefits and potential impacts associated with the implementation of the SJRRP were analyzed in the San Joaquin River Restoration Program Environmental Impact Statement/Report (PEIS/R) and Programmatic Biological Assessment (SJRRP 2011a).

The SJRRP's Restoration Area includes a 149–mile section of the San Joaquin River from Friant Dam to the Confluence with the Merced River in Fresno and Madera counties, California. The SJRRP's Restoration Area is divided into separate reaches (Figure 1). In order to implement the SJRRP, a comprehensive strategy for the conservation of listed and sensitive species and habitats—termed the Conservation Strategy—was prepared in coordination with the SJRRP Implementing Agencies, which consist of the U.S. Department of the Interior, Bureau of Reclamation (Reclamation); U.S. Fish and Wildlife Service (USFWS); National Marine Fisheries Service (NMFS); California Department of Fish and Wildlife (DFW); and California Department of Water Resources (DWR).

This biological assessment (BA) analyzes the potential effects of the Mendota Pool Bypass and Reach 2B Improvements Project (Project) for consultation with NMFS. Based on historically and recently collected data of species occurrence, distribution, and habitat, the following threatened or endangered species could be affected by the Project and therefore are addressed in this BA:

- Central Valley steelhead Distinct Population Segment (DPS; *Oncorhynchus mykiss*), federally listed as threatened
- Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU; *O. tshawytscha),* federally listed as a nonessential experimental population in the Action Area

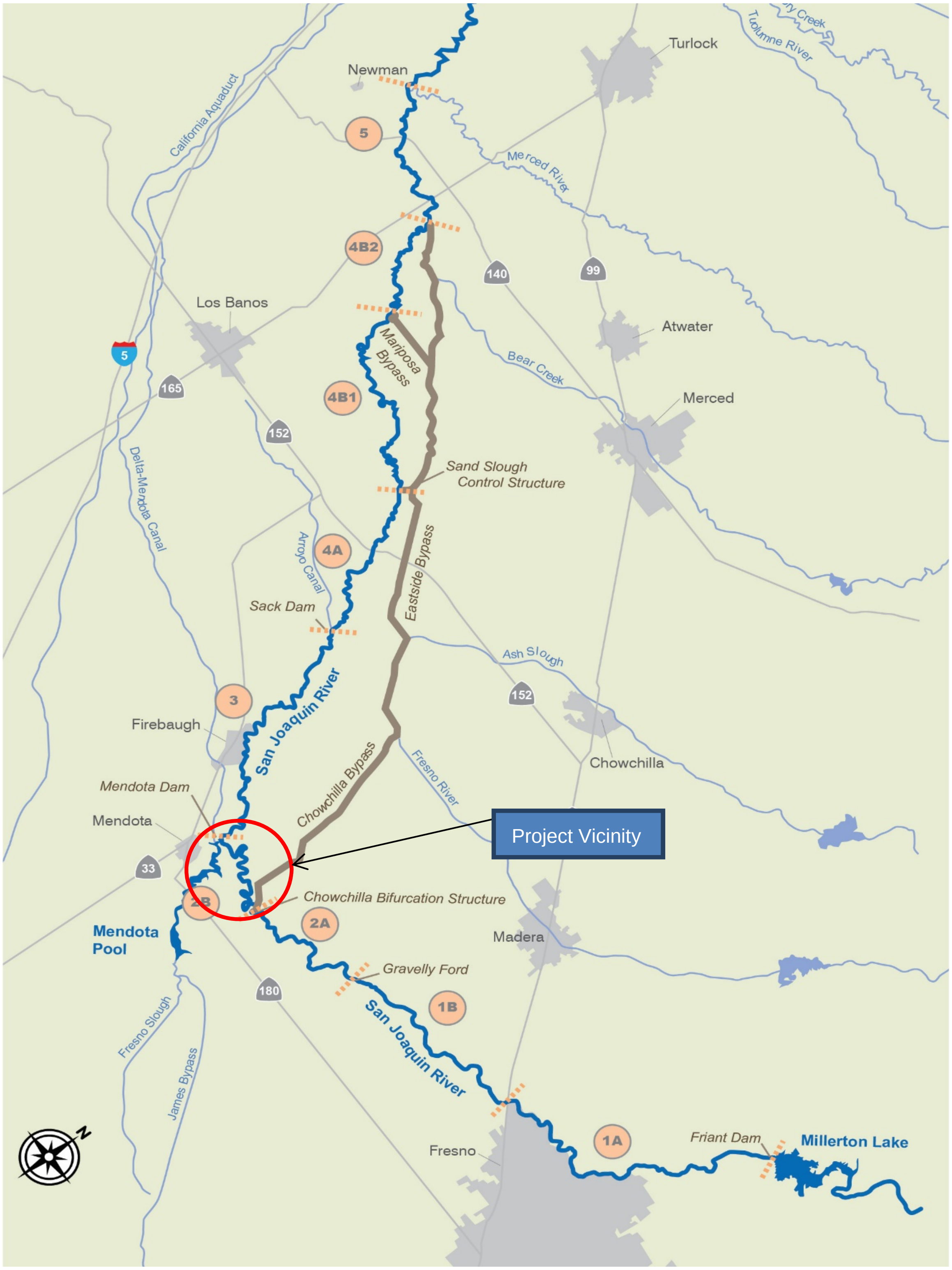

Figure 1.
Overview of the SJRRP Restoration Area and the Project Vicinity

NMFS has designated spring-run Chinook salmon being reintroduced to the San Joaquin River as a non-essential experimental population (NEP) in accordance with Section 10(j) of the Endangered Species Act (ESA). Therefore, Section 7(a)(2) of the ESA does not apply, and the species is treated under the ESA as a species proposed for listing. No proposed or designated critical habitat occurs within the action area for either Central Valley steelhead or Central Valley spring-run Chinook salmon. Reclamation is requesting a formal consultation with NMFS under Section 7(a)(2) of the Federal Endangered Species Act (ESA) for Central Valley steelhead and informal conference under Section 7(a)(4) for Central Valley spring-run Chinook salmon.

NMFS has designated the San Joaquin River, including the proposed Action Area, as Essential Fish Habitat (EFH) for Pacific salmon in accordance with the Pacific Coast Salmon Fishery Management Plan (FMP) under the Magnuson-Stevens Fishery Management and Conservation Act (MSFCMA) (NOAA 2015). This BA also analyzes the potential effects of the Project on Pacific salmon EFH.

1.1 Consultation History

Coordination between Reclamation and NMFS regarding the SJRRP has occurred regularly since 2008. The SJRRP Programmatic BA contains a detailed record of Environmental Compliance Permitting and Work Group meetings, ESA and California Endangered Species Act meetings, and correspondence between NMFS and Reclamation between March 2008 and August 2011 (SJRRP 2011a). Reclamation submitted a Programmatic BA in November 2011 (SJRRP 2011a) and NMFS issued a biological opinion (BO) in September 2012 (NMFS 2012). NMFS has regularly participated in other SJRRP work group meetings, including the Fisheries Management Work Group, the Water Management Work Group, and the Restoration Goals Work Group, both prior to the submission of the Programmatic BA and since. A draft Reach 2B BA was provided to NMFS in July 2015 for review and coordination.

On September 29, 2015, a meeting with NMFS, USFWS, Reclamation, and AECOM was held at the SJRRP Conference Room in Sacramento, California. The purpose of the meeting was to discuss the addition of a Fish Rescue Plan; the Central Valley spring-run Chinook salmon experimental population; more information on operation, maintenance, construction methods, and schedule; and potential take of listed species in the BA. NMFS provided written comments on the July 2015 Draft BA to Reclamation on October 16, 2015, following this meeting.

On October 27, 2015, a meeting with NMFS, Reclamation, and AECOM was held at the SJRRP Conference Room in Sacramento, California. The purpose of the meeting was for Elif Fehm-Sullivan, NMFS biologist, to provide guidance regarding steelhead take calculations, addressing Central Valley spring-run Chinook salmon as an experimental population, and details on fish rescue and relocation, planting, and hydroacoustic plans.

On November 17, 2015, NMFS and AECOM attended a presentation by Reclamation on Compact Bypass 30% design held in Merced, California.

On November 23, 2015 Reclamation provided a revised draft BA and comment response to NMFS which addressed NMFS comment on the July 2015 draft.

On December 3, 2015, a meeting with NMFS (Rhonda Reed, Elif Fehm-Sullivan, and Hilary Glenn), Reclamation (Katrina Harrison, Elizabeth Vasquez, Rebecca Victorine, and Andrew Minks) and AECOM was held at the SJRRP Conference Room in Sacramento, California. The purpose of the meeting was to review the working draft BA, discuss incidental take calculations for Central Valley steelhead and entrainment estimate of Central Valley spring-run Chinook salmon in Mendota Pool. Reclamation and AECOM addressed minor comments from NMFS in the document and arranged to address major comments prior to resubmitting the BA to NMFS to initiate formal consultation.

1.2 Proposed Action

The Mendota Pool Bypass and Reach 2B improvements defined in the Settlement are (Settlement Paragraph 11[a]):

> *(1) Creation of a bypass channel around Mendota Pool to ensure conveyance of at least 4,500 cubic feet per second (cfs) from Reach 2B downstream to Reach 3. This improvement requires construction of a structure capable of directing flow down the bypass and allowing the Secretary to make deliveries of San Joaquin River water into Mendota Pool when necessary;*
>
> *(2) Modifications in channel capacity (incorporating new floodplain and related riparian habitat) to ensure conveyance of at least 4,500 cfs in Reach 2B between the Chowchilla Bifurcation Structure and the new Mendota Pool bypass channel.*

Because the functions of these channels may be interrelated, the design, environmental compliance, and construction of the two are being addressed as one project. The Project would be implemented consistent with the Settlement and the Act, Public Law 111-11.

The Mendota Pool Bypass would include conveyance of at least 4,500 cfs around Mendota Pool from Reach 2B to Reach 3 (Figures 2 and 3). This action would also include constructing a bifurcation structure in Reach 2B to divert up to 2,500 cfs to the Mendota Pool. The bifurcation structure would be designed to direct fish into the bypass channel and minimize or avoid fish entrainment to the Mendota Pool.

Improvements to Reach 2B would include modifications to the San Joaquin River channel from the Chowchilla Bypass Bifurcation Structure to the Compact Bypass bifurcation structure to provide a capacity of at least 4,500 cfs, with integrated floodplain habitat. New levees would be constructed along Reach 2B to increase the channel capacity while allowing for new floodplain habitat.

The Action Area includes areas directly and indirectly affected by the Project, including the entire Project footprint shown in Figures 2 and 3, and extends from the Chowchilla Bypass Bifurcation Structure to approximately 1 mile downstream of Mendota Dam. The Action Area is in Fresno and Madera counties, near the town of Mendota.

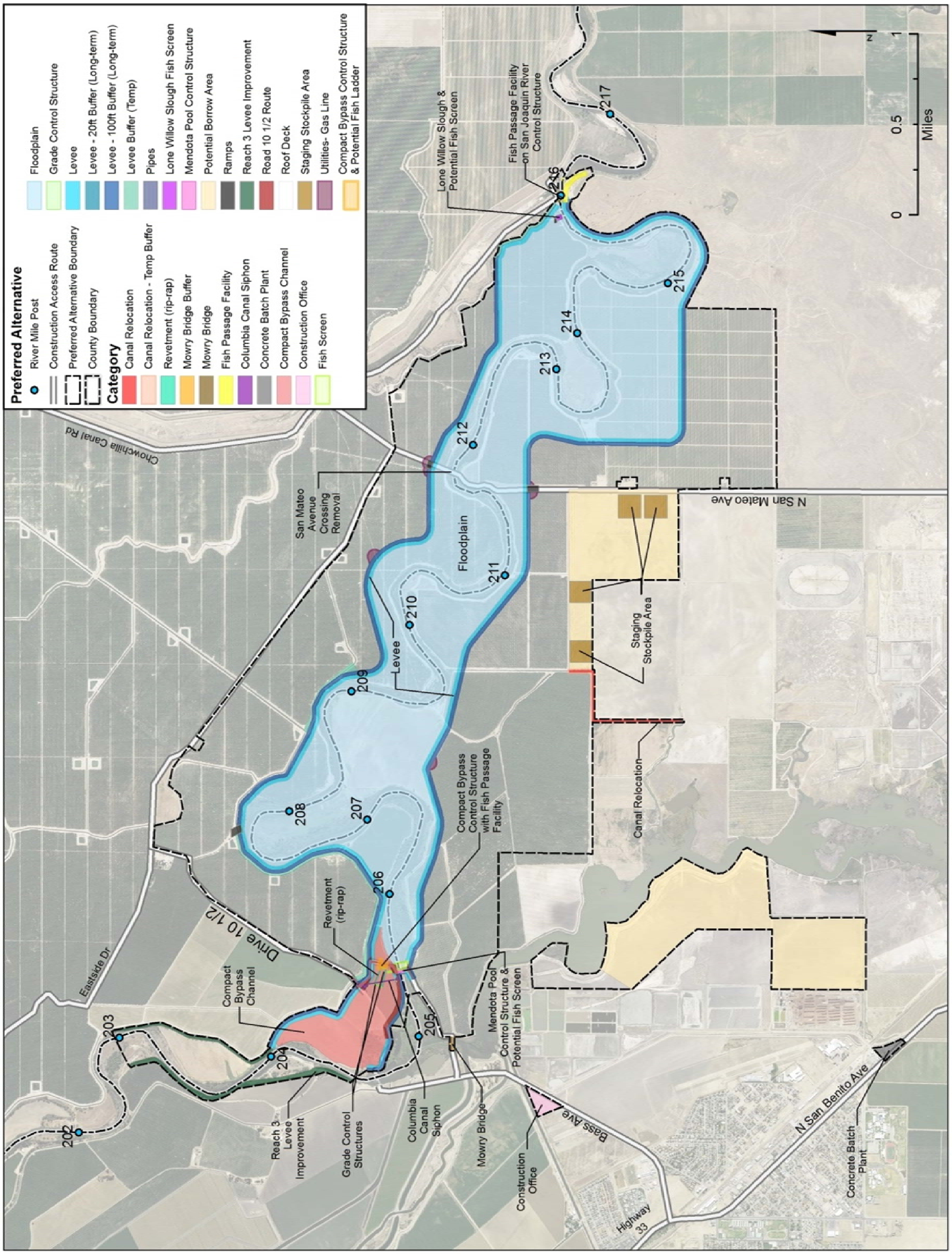

Figure 2.
Plan View of Project

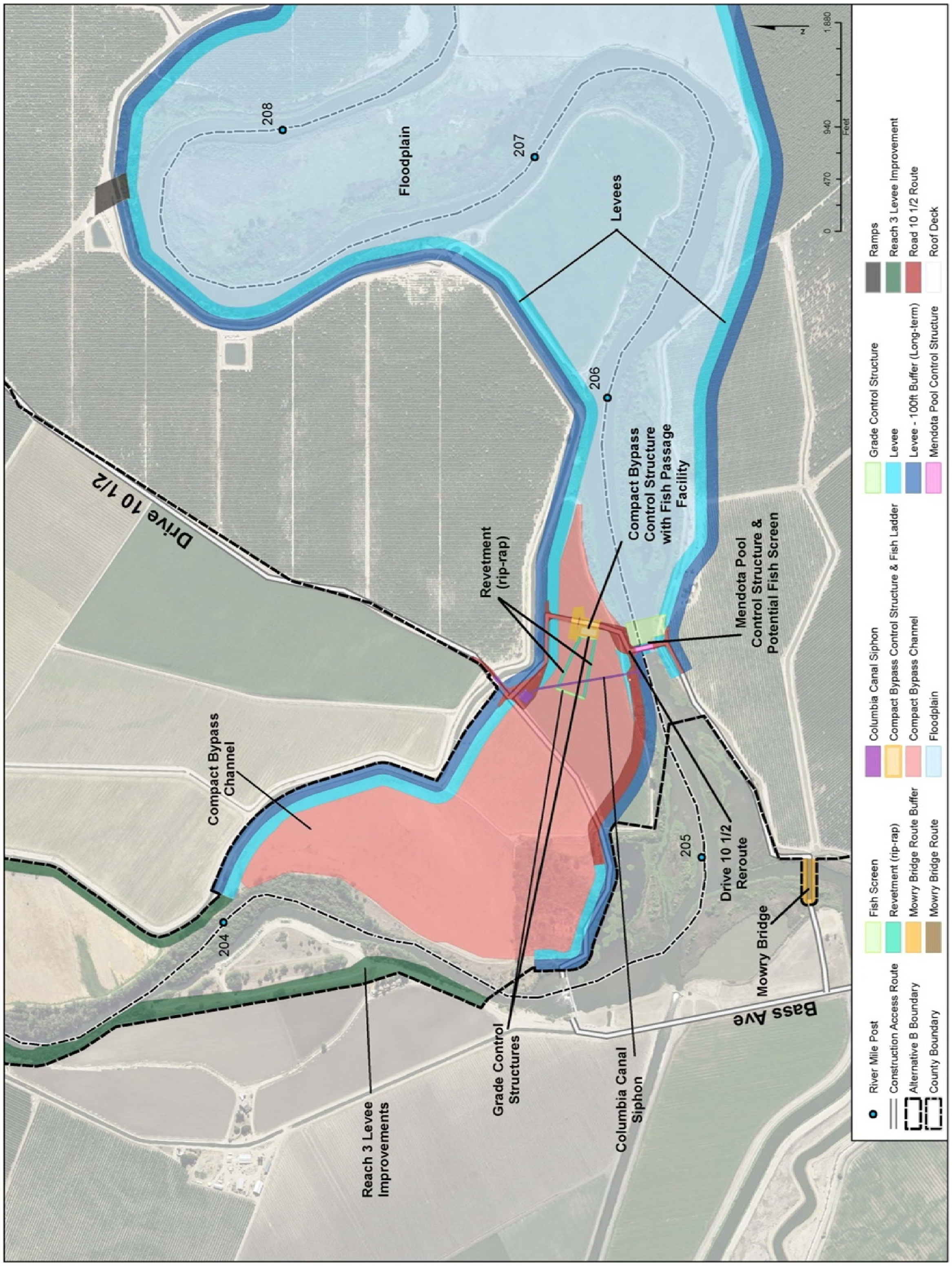

Figure 3.
Inset Map of Project

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2.0 Project Description

2.1 Action Area

The action area includes the area that may be directly or indirectly affected by the project. This includes Reach 2B, a section of the San Joaquin River which begins at the Chowchilla Bifurcation Structure and ends at Mendota Dam, about 1,800 linear feet of river upstream of the Chowchilla Bifurcation Structure, about 1 mile of the river downstream of Mendota Dam, and a portion of Fresno Slough. Additionally, the action area extends beyond the project footprint to areas where site-specific activities may cause increased turbidity and high levels of noise.

2.2 Proposed Action

The Project includes:

- Building setback levees capable of conveying flows up to 4,500 cfs with 3 feet of freeboard, and breaching portions of the existing levees.
- Restoring floodplain habitat with an average width of approximately 4,200 feet to provide benefit to salmonids and other native fishes.
- Constructing a channel and structures capable of conveying up to 4,500 cfs of Restoration Flows around the Mendota Pool.
- Constructing structures capable of conveying up to 2,500 cfs from Reach 2B to Mendota Pool.
- Providing upstream and downstream fish passage for adult salmonids and other native fishes, and downstream fish passage for juvenile salmonids, between Reach 2A and Reach 3.

The Project would construct a channel between Reach 2B and Reach 3, the Compact Bypass channel, in order to bypass the Mendota Pool. Restoration Flows would enter Reach 2B at the Chowchilla Bifurcation Structure, flow through Reach 2B, then downstream to Reach 3 via the Compact Bypass channel. The existing Chowchilla Bifurcation Structure would continue to divert San Joaquin River flows into the Chowchilla Bypass during flood operations, and a fish passage facility and control structure modifications would be included at the San Joaquin River control structure at the Chowchilla Bifurcation Structure. This action would also include constructing two new structures in Reach 2B, the Compact Bypass control structure and the Mendota Pool control structure (collectively referred to as the Compact Bypass Bifurcation Structure), to divert up to 2,500 cfs to the Mendota Pool. Fish passage facilities would be built at the Compact Bypass control structure to provide passage around the structure when gates are closed during times of water delivery. Most of the time, fish would pass through the Compact Bypass control structure into the bypass channel and gates would be closed on the Mendota Pool control structure, preventing fish entrainment to the Mendota Pool. The existing crossing at the San Mateo Avenue would be removed. These features are described in further detail in the sections below. See Figures 2 and 3 for a plan view of the Project's features.

2.2.1 Compact Bypass Channel

The bypass channel would convey 4,500 cfs around the Mendota Pool by constructing a channel just southwest of the existing Columbia Canal alignment. Once constructed, the bypass channel would become the new river channel. The Project includes excavating the bypass channel, constructing setback levees and in-channel structures, breaching existing levees but leaving some segments that provide valuable habitat in place, relocating or modifying existing infrastructure, and acquiring land. The in-channel structures include the Compact Bypass control structure, Mendota Pool control structure, grade control structures, fish passage facility at the Compact Bypass control structure, Columbia Canal siphon and pumping plant, as well as the Drive 10 ½ realignment and are discussed under Structures. The bypass channel and associated structures provide downstream passage of juvenile Chinook salmon and upstream passage of adult Chinook salmon, as well as passage for other native fishes, while isolating Mendota Pool from Restoration Flows. A fish screen upstream of the Mendota Pool Control Structure is included in the Project Draft Environmental Impact Statement/Report (SJRRP 2015a) and will be included in the USFWS BA. However, because the fish screen may not be installed, this BA assumes that the worst case scenario (i.e., no fish screen) will occur for the purposes of evaluating Project impacts to fish and aquatic habitat.

The bypass channel would connect to Reach 3 approximately 0.6 mile downstream from Mendota Dam (approximately River Mile [RM] 204), bypass the Mendota Pool to the north, and connect to Reach 2B approximately 0.9 mile upstream from Mendota Dam (approximately RM 205.5). The bypass channel would have a total length of approximately 0.8 mile. A siphon under the bypass channel would be constructed to connect the Columbia Canal to the Mendota Pool.

The bypass channel would be a multi-stage channel designed to facilitate fish passage at low flows, channel stability at moderate flows, and contain high flows. The low flow channel is approximately 70 feet wide and has an average depth of approximately 3 feet deep. It is designed to contain approximately 200 cfs (Figure 4), and is sinuous. The overbank slopes toward the low flow channel. The bank slope of 67 feet horizontal to 1 foot vertical (67H:1V) and a flow of 1,200 cfs is designed to have about 1 foot of depth in the overbank. The overbank slope increases to 20H:1V at a distance of 135 feet from the center of the channel. The floodplain is intended to produce a range of channel depths regardless of the flow.

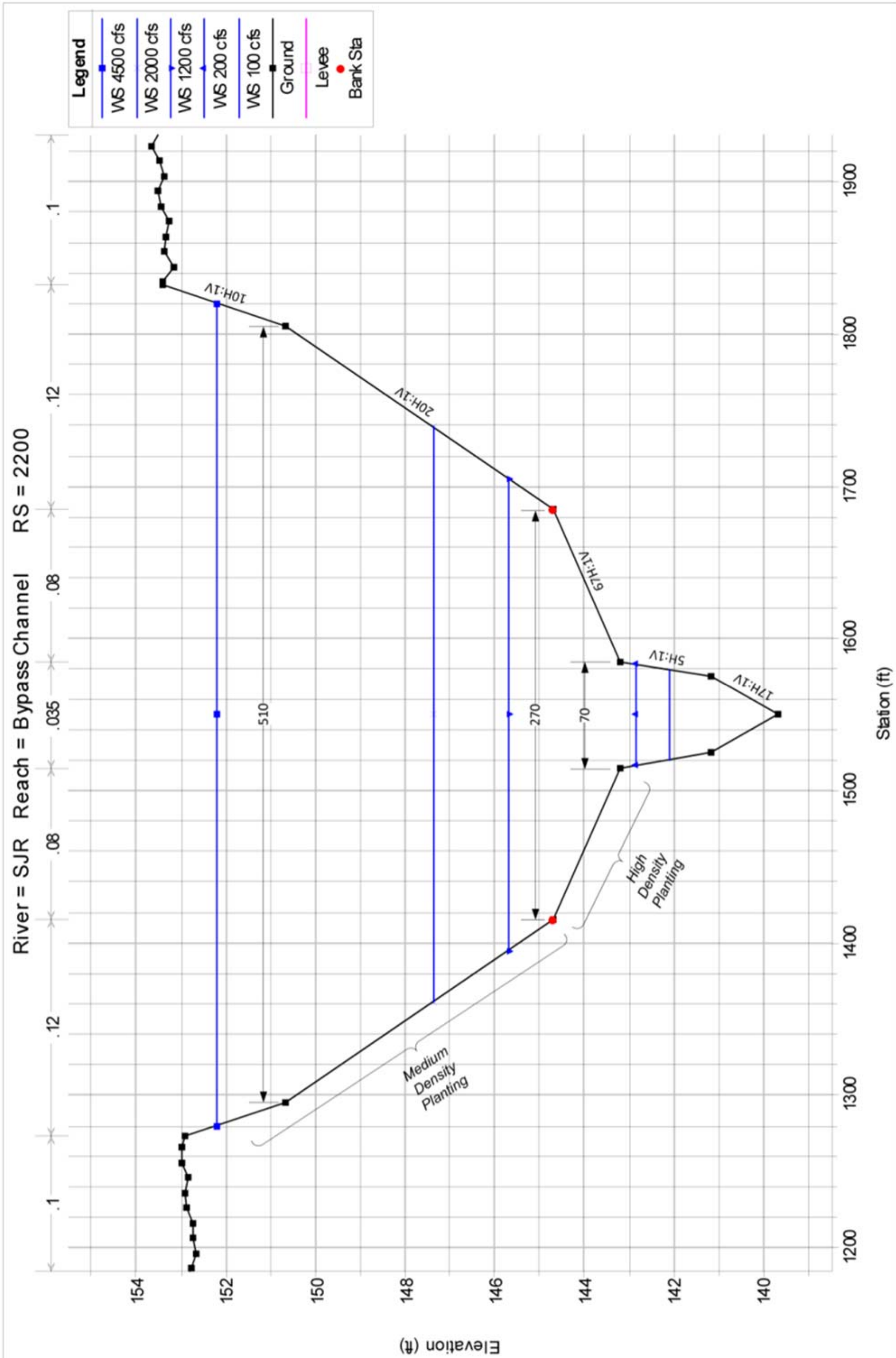


Figure 4.
Typical Cross Section in Compact Bypass

The elevation of the Compact Bypass control structure is set at 141 feet in order to promote sediment stability throughout Reaches 2 and 3 and minimize the need for grade control in the Compact Bypass. Because the entrance to the bypass is located approximately 7 feet below the current thalweg of Reach 2B, a pilot channel would be constructed to create a smoother transition between Reach 2B and the bypass channel (Figure 5; shown in red) and reduce sedimentation downstream into Reach 3. The pilot channel would be a 70-foot-wide channel with 2H:1V side slopes. It would be excavated within Reach 2B, upstream of the junction between the bypass and San Joaquin River. The excavation would be performed just prior to the reintroduction of high flows to the bypass so that sediment does not refill the channel. Some of the material excavated from the pilot channel could be placed in the bed of the low flow channel located in the bypass to a maximum depth of 1 foot.

The Compact Bypass channel, designed as an unlined earthen channel, would be approximately 4,000 feet long with a total corridor width of approximately 510 feet. The average slope of the channel would be approximately 0.0005 (approximately 2.6 feet per mile), while the total elevation drop in the Compact Bypass after channel stabilization would be approximately 2 feet. Two grade-control structures just downstream of the Compact Bypass control structure would be included to achieve the necessary elevation change (see Grade Control Structures). Channel complexity is incorporated as appropriate per the Rearing Habitat Design Objectives.

2.2.2 Structures

The structures described below would be required to provide the operational flexibility to divert water to the Mendota Pool, provide fish passage, allow maintenance access to Mendota Dam, prevent fish entrainment and straying, and provide controlled elevation drop between Reach 2B and Reach 3.

Fish Passage Facility on the San Joaquin River Control Structure at the Chowchilla Bifurcation Structure

The existing San Joaquin River control structure at the Chowchilla Bifurcation Structure would not be passable by up-migrating salmon and native fish for all flows and flow splits between the river and the Chowchilla Bypass. The undershot gates, sill across the downstream side of the structure, and trash rack on the upstream side contribute to upstream passage difficulties at high, low, and all flows, respectively. A fish passage facility would be required for upmigrating salmon and other native fish to swim into Reach 2A from Reach 2B under most conditions.

Passage Facility Design

The design of the fish passage facility would be based on criteria in *Anadromous Salmonid Passage Facility Design* (NMFS 2008). The size and geometry of the fish passage facility would be dictated by the flow requirements for juvenile and adult fish (see Table 1). Several types of fish passage facility may be considered in detailed design: vertical slot weir ladder design was included for its ability to accommodate a greater range of water depths (hydraulic head at the upstream and downstream ends), but the design may also consider ice-harbor, pool and chute, rock ramp fishway or other passage facility designs.

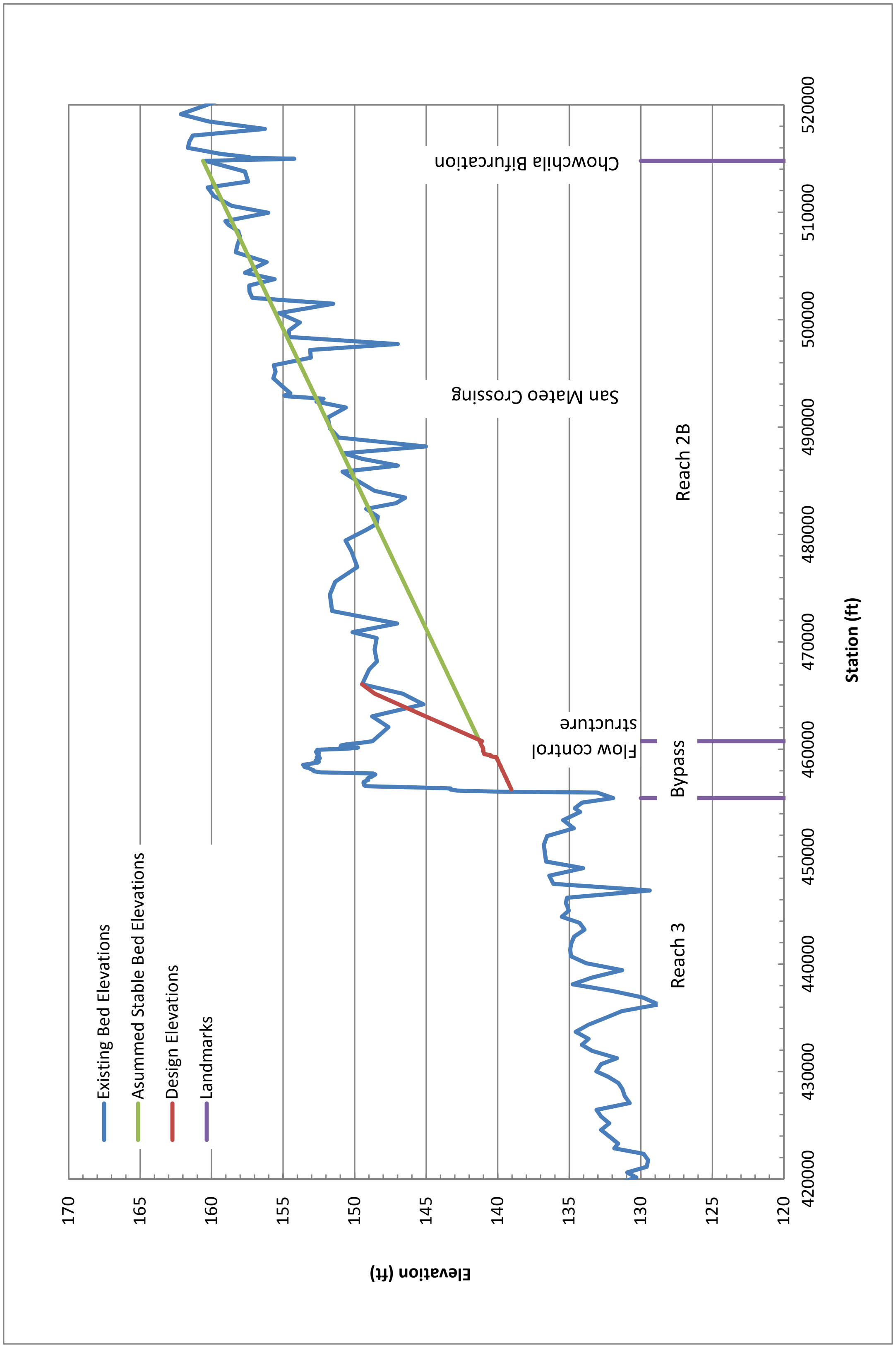


Figure 5.
Existing and Design Profiles in Reach 2B through the Compact Bypass

Attraction Flows. The attraction flow magnitude would be 5 to 10 percent of the total flow through the control structure over the path of Restoration Flows. The Project requires conveyance of at least 4,500 cfs, so the attraction flow at the passage facility entrance could be as high as 450 cfs. The passage facility itself may have a design flow rate less than the maximum attraction flow. In this case, the balance of attraction flows could be provided at the passage facility entrance (downstream side) through supplementary water, described below.

Supplementary Water. Supplementary water, if incorporated into the facility, is water already in the river and which is piped to the fish passage facility entrance to augment attraction flows (see Figure 6). No additional water supply beyond what would be flowing in the river is required. The supplementary water allows the passage facility to operate under a wider range of river flows by supplying additional attraction flow when the need exceeds the design flow rate through the passage facility. Supplementary water would also be used to control the hydraulic head at the passage facility entrance. Supplementary flow would be collected by a water delivery intake structure located upstream from the fish passage facility. The intake structure would include a trash rack and a fish screen to prevent migrating fish from entering the intake. River water would enter the intake structure, and travel downriver through pipes to the passage facility entrance.

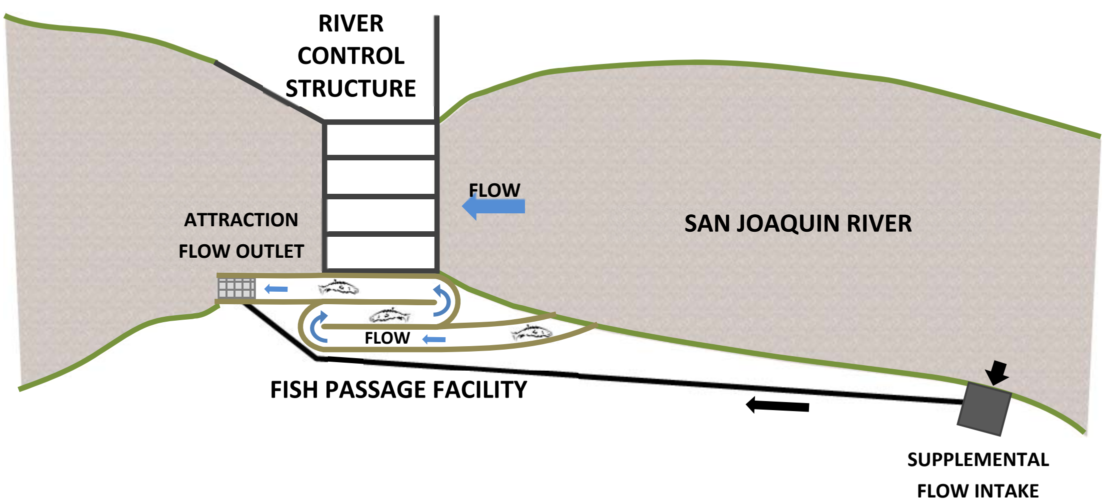


Figure 6.
Supplementary Flow System Plan-view Diagram

San Joaquin River Control Structure at the Chowchilla Bifurcation Structure Modifications

In addition to the passage facility, the San Joaquin River control structure at the Chowchilla Bifurcation Structure would be modified to improve fish passage through the control structure itself or to improve operations of the passage facility. Fish passage through the modified river control structure may meet passage criteria only for certain flows, so the fish passage facility described above would still be required.

Improvements to the river control structure could include removing the trash racks, replacing one or more radial gates with over-shot gates (e.g., inflatable Obermeyer weir gates), notching or removal of the baffle wall or weir, removing the dragon's teeth, and replacing or modifying the scour protection. Improvements would be designed based on NMFS 2001 and NMFS 2008 passage criteria. Improvements would not affect the ability of the structure to divert flood water into the Chowchilla Bypass.

San Mateo Avenue Crossing Removal

The San Mateo Avenue crossing is an existing river crossing located within a public right-of-way in Madera County and on private land in Fresno County at approximately RM 211.8. The crossing transitions from public right-of-way to private land at the center of the river. The crossing consists of a low flow or dip crossing with a single culvert. As part of the Project, the culvert and road embankments would be demolished, and no river crossing would be provided at this location.

Compact Bypass Bifurcation Structure

A bifurcation structure would be constructed at the upstream end of the Compact Bypass. The bifurcation structure consists of two control structures: one across the path of Restoration Flows (Compact Bypass), also known as the Compact Bypass Control Structure, and one across the path of water deliveries to Mendota Pool (San Joaquin River), also known as the Mendota Pool Control Structure.

The Compact Bypass Control Structure includes a fish passage facility on the side of the structure (i.e., the Compact Bypass Fish Passage Facility). Each control structure would be placed in the middle of the channel and has earthen embankments, which are designed as dams as they may have water on both sides, connecting the structure to the proposed levees. A 16-foot-wide roadway and 20-foot-wide maintenance/operations platform would be provided over each control structure.

Compact Bypass Control Structure. The Compact Bypass Control Structure would be designed to accommodate up to 4,500 cfs and consists of eight 14-foot-wide bays. Conditions in this control structure would be designed based on *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001) and *Anadromous Salmonid Passage Facility Design* (NMFS 2008) fish passage criteria. The bays would be outfitted with radial gates. Approximately 95 percent of the time, fish and Restoration Flow would pass through this structure and all gates would be open.

When deliveries are occurring, most of the gates of the Compact Bypass Control Structure would be shut nearly all the way. The water surface elevation would increase by several feet on the upstream side of the structure. The gates of the Mendota Pool Control Structure would open and water would be delivered to Mendota Pool. In the delivery situation, fish and Restoration Flows would pass primarily through the fish passage facility, described below. Water that passes through the Compact Bypass Control Structure would be forced through a small opening, and a hydraulic jump would form downstream of the structure. A stilling basin would be located on the downstream side of the Compact Bypass Control Structure to contain the hydraulic jump that would form when deliveries are occurring to Mendota Pool.

Mendota Pool Control Structure. The control structure across the San Joaquin River (the path of the water deliveries) would be designed to accommodate up to 2,500 cfs. The structure would have twelve bays that are 10 feet wide, and would contain slide gates to control the flow of water rather than radial gates, since Mendota Pool would be impounded on the downstream side of the structure at all times. Guides for stop logs would be provided in all bays to allow for maintenance. A 5-foot barrier wall would be provided that could be added to the upstream side of the structure in several decades, to allow continued operation with subsidence.

Compact Bypass Fish Passage Facility

The Compact Bypass control structure (across the Restoration Flow path) includes a fish passage facility. The fish passage facility would be necessary to provide passage during water deliveries. The design of the fish passage facility is a vertical slot ladder with a sloped bottom, with approximately 12H:1V slope, 12 feet of drop across the fish passage facility, and approximately 3 feet of flow depth. Fish would only pass through this facility when deliveries are occurring to Mendota Pool, approximately 5 percent of the time when fish could be present. Approximately 95 percent of the time, fish would migrate through the Compact Bypass Control Structure bays under the open gates.

Drive 10 ½ Crossing

The Compact Bypass would cross existing Drive 10 ½, which provides access for the operations and maintenance of Mendota Dam. To continue the current level of access, the road would be rerouted along the bypass channel levees and cross the head of the bypass channel at the proposed Compact Bypass bifurcation structure. A road deck would also be provided over the fish passage facility adjacent to the bifurcation structure. The road would be designed for HS-20 loading (e.g., sufficient to allow transport of a 25-ton maintenance crane to Mendota Dam).

Columbia Canal Facilities

The Columbia Canal water intake facility would be located in Mendota Pool, and likely would consist of eight 15-foot-wide, 7-foot-tall bays, with a bar screen to prevent aquatic vegetation entering the siphon. The extensive intake area would be required to maintain appropriate velocities and minimize sediment and vegetation issues. Intake bays would be 7 feet tall to account for 5 feet of subsidence. Existing water surface elevations in Mendota Pool would rise to approximately 2 feet above the intake crest elevation. The bar screen would be cleaned by an automatic trash rake. A sediment sump would be provided in the center bay to allow for sediment removal. The top of the intake facility would be covered with grating to allow for easy access for maintenance.

The Columbia Canal siphon would cross underneath the Compact Bypass from the intake facility on Mendota Pool to the pumping plant located near the existing Columbia Canal, approximately 1,000 feet. The siphon would be two adjacent 4-foot by 6-foot concrete box culverts, that would be buried a minimum of 5 feet below the low flow channel in the Compact Bypass. The discharge facility for the Columbia Canal siphon would be located where Drive 10 ½ crosses the Columbia Canal, on the north side of the future Compact Bypass (Figure 7). The pumping plant would be located adjacent to this facility. The Columbia Canal intake facility and pumping plant would be constructed with SCADA (supervisory control and data acquisition) capability, but able to be manually operated as well. The pumping plant would include a steel plate door and cinder block walls and would be enclosed within a fenced and gated area to minimize vandalism.

Electronics Building

A separate, approximately 12-foot by 10-foot electronics building would house power controls for trash rack cleaning systems, fish monitoring equipment, SCADA, etc. The building would be located adjacent to the Columbia Canal pumping plant, or on the other side of the Compact Bypass near the Mendota Pool Control Structure. The building would include a steel plate door and cinder block walls and would be enclosed within a fenced and gated area to minimize vandalism.

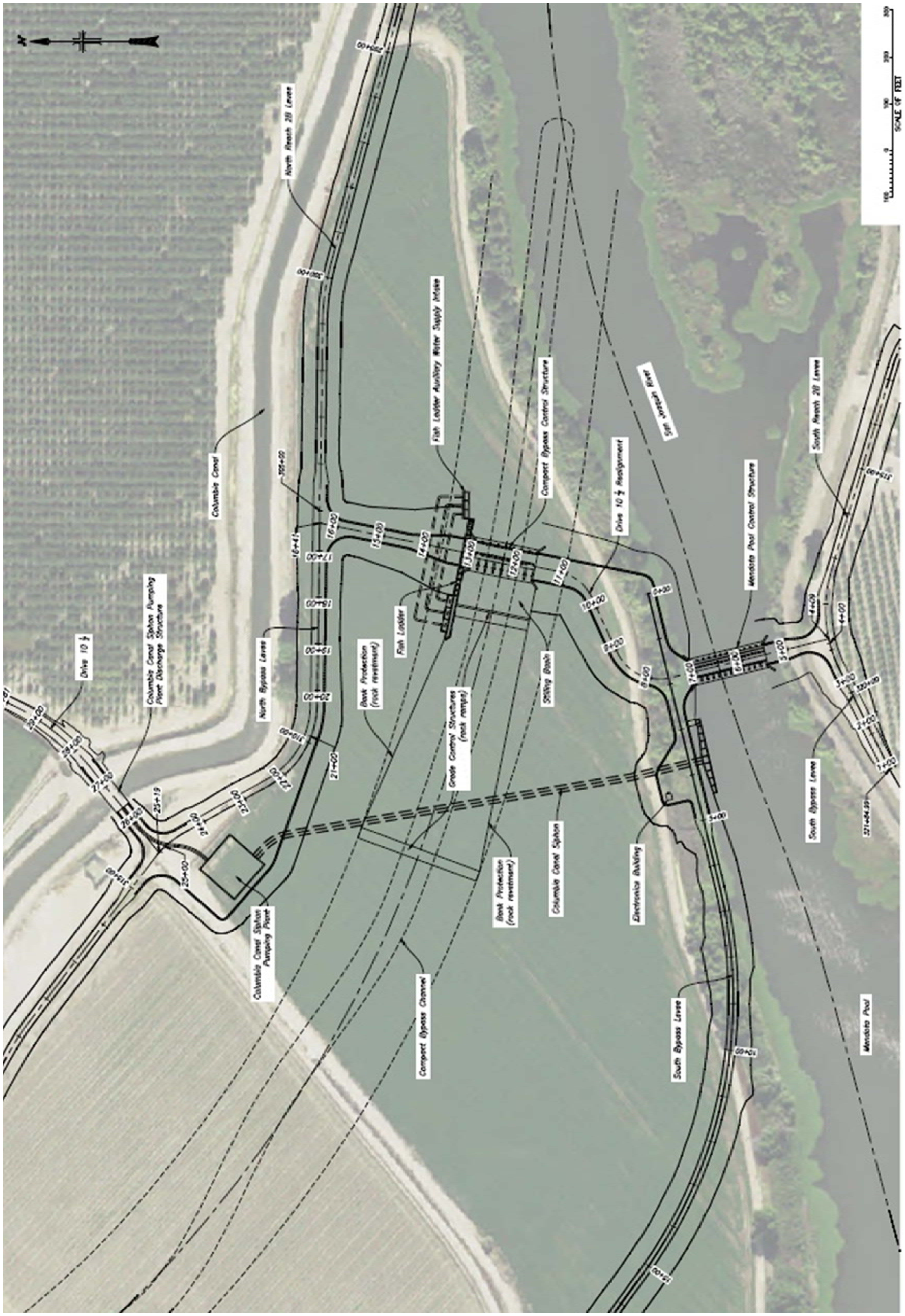


Figure 7.
Preliminary Site Plan for the Compact Bypass Structures

Grade Control Structures

There would be two grade control structures, designed as rock ramps per the *Rock Ramp Design Guidelines* (Reclamation 2007) and *Hydraulic Design of Flood Control Channels, EM 1110-2-1601* (Corps 1994). The most upstream one would be located immediately downstream of the Compact Bypass Control Structure. The second grade control structure would be located near the Columbia Canal siphon crossing. The siphon crossing would be located approximately underneath the second grade control structure so that the grade control structure would also serve to protect the siphon crossing. Each grade control structure would have approximately 0.4 feet of drop across it. Each structure would have a maximum downstream slope of 0.04 and be a minimum of 25 feet in length in the streamwise direction (see Figure 8). Rocks would be approximately 12 inches in diameter. Two filter layers would be constructed underneath the rock ramps, one of gravel and one of sand.

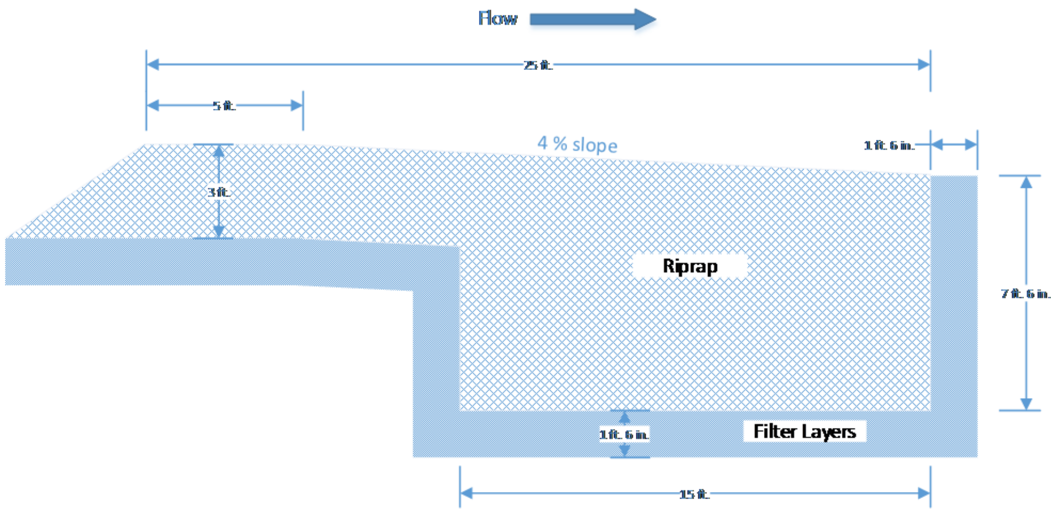


Figure 8.
Conceptual Profile View of Grade Control Rock Ramps

Rock riffles have benefits for native fish migration, but they present construction challenges in the sandy substrate of the Reach 2B and Reach 3 area. The flow over constructed rock riffles may reduce the disorienting effects on juveniles from rapidly changing hydraulics otherwise created at weir structures, and they are more favorable to sturgeon, which do not jump. Constructed rock riffles may be less favorable to predators which can hold in the quiescent pools below weir structures. However, placing rock in sandy substrate requires engineered foundation materials (layers of rock in gradually decreasing sizes) to prevent undermining the structure.

Each grade control structure would extend across the main channel and key into the overbanks to protect against flanking, resulting in a total structure width of about 220 feet.

Bank protection measures would be incorporated into the bypass between the Compact Bypass Control Structure and the downstream most grade control structure, totaling about

500 linear feet of bank protection on either side of the Compact Bypass channel. Downstream of the grade control structure, no bank protection would be necessary after establishment of riparian vegetation. Bank protection measures could include: vegetated revetment, rock vanes, bioengineering techniques, and riparian vegetation. It is assumed that the vegetated revetment would consist of buried riprap of approximately 12 inches in diameter, covered with topsoil, erosion control fabric, and native woody vegetation, so that fish would experience natural channel banks. Rock vanes would be constructed to only interact with the flow if erosion occurs (i.e., the top of the vane would be level with the constructed overbank surface). Bioengineering techniques could include vegetated geogrids, fabric encapsulated soil banks, brush mattresses, and root wads. Native woody vegetation directly upstream, downstream, and adjacent to the grade control structures would provide shading and opportunities for juveniles to hide from predators.

2.2.3 Fish Passage Criteria

The Project includes provision of fish passage at structures for salmonids and other native fish. These structures include fish passage facilities, grade control structures, and bifurcation structures (under certain flows). The designs for structures with fish passage components would be based on criteria in *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001). Specifically, the Project would provide suitable hydraulic conditions for passage of up-migrating adult salmonids, out-migrating juvenile salmonids, and some inter-reach migration of other native fish between Reach 2A and Reach 3. Suitable hydraulic conditions include those conditions which the species is physically capable of passing and do not cause undue stress on the animal. The passage features would be designed to cause no physical harm to fish. The design criteria are structured around the life stages of the target anadromous species and the timing of the runs for upstream movement of adult fall and spring run Chinook and winter steelhead and the downstream movement of juvenile life stages spawned from these runs. Recommended criteria are based on a combination of swimming ability of the fish species as reported in scientific papers and criteria in agency design guidelines. Recommended design criteria to provide for successful fish passage (depth of flow, suitable velocity ranges and jump height) are provided in Table 1. The design criteria for a particular species would be met over the associated flow range (minimum flow to maximum flow). For sturgeon, lamprey, and other native fish, criteria would be met for some portion of the applicable fish migration period.

Table 1.
Fish Passage Design Criteria

Species	Life-stage	Migration Timeframe	Frequency	Minimum Flow	Maximum Flow	Maximum Velocity [1]	Minimum Water Depth [2]	Maximum Jump Height [3]	Minimum Pool Depth
			years	cfs	cfs	fps	feet	feet	feet
Chinook salmon	Adult	Spring and fall pulse	All years except CL	115 [4]	4,500	4.0	1.0	1.0	[5]
	Juvenile (downstream)	Nov-May	All years except CL	85 [6]	n/a	n/a	1.0	n/a	[5]
Steelhead	Adult	Spring and fall pulse	All years except CL	115 [4]	4,500	4.0	1.0	1.0	[5]
	Juvenile (downstream)	Nov-May	All years except CL	85 [6]	n/a	n/a	1.0	n/a	[5]
Sturgeon	Adult	Spring pulse	W and NW years	-	-	6.6	3.3	None – swim through	n/a
Lamprey	Adult	Spring pulse	All years except CL	-	-	[7]	[7]	[7]	n/a
Other native fish	Adult	Spring pulse	W, NW, and ND years	-	-	2.5 [8]	1.0 [8]	None – swim through	n/a

W = wet; NW = normal wet; ND = normal dry; CL = critical low

[1] Recommended maximum velocities shown are for grade control structures or structures with short longitudinal lengths based on *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001). For structures with longer lengths (e.g., culverts and bifurcation structures under certain conditions), maximum velocities would be developed based on criteria in *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001).

[2] Minimum water depth criteria based on 1.5 times body depth or 1 foot depth, whichever is greater based on *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001).

[3] Maximum jump height criteria based on criteria in *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001).

[4] Based on Exhibit B lowest flow in the fall spawning period (starts Oct 1) for the desired frequency; all Spring Pulse Flows are higher.

[5] Pool depths to be based on criteria in *Anadromous Salmonid Passage Facility Design* (NMFS 2008) and *Guidelines for Salmonid Passage at Stream Crossings* (NMFS 2001).

[6] Based on lowest flow within desired migration period for the desired frequency.

[7] Lamprey designs to be based on criteria in *Best Management Practices for Pacific Lamprey* (USFWS 2010)

[8] Based on hardhead and hitch.

The Project includes facilities that fish would encounter or need to pass to migrate between Reach 3 and Reach 2A (from downstream to upstream). The need for fish screens at diversion facilities would be further evaluated as Project planning and design continues. Fish screens at diversion facilities, including at Lone Willow Slough, Big and Little Bertha pumps, and smaller diversions, are discussed in the Project Draft Environmental Impact Statement/Report (SJRRP 2015a) and will be included in the USFWS BA. However, because the fish screens may not be installed, this BA assumes that the worst case scenario (i.e., no fish screen) will occur for the purposes of evaluating Project impacts to fish and aquatic habitat.

During construction, impacts to fish would be minimized by including some or all of the following measures:

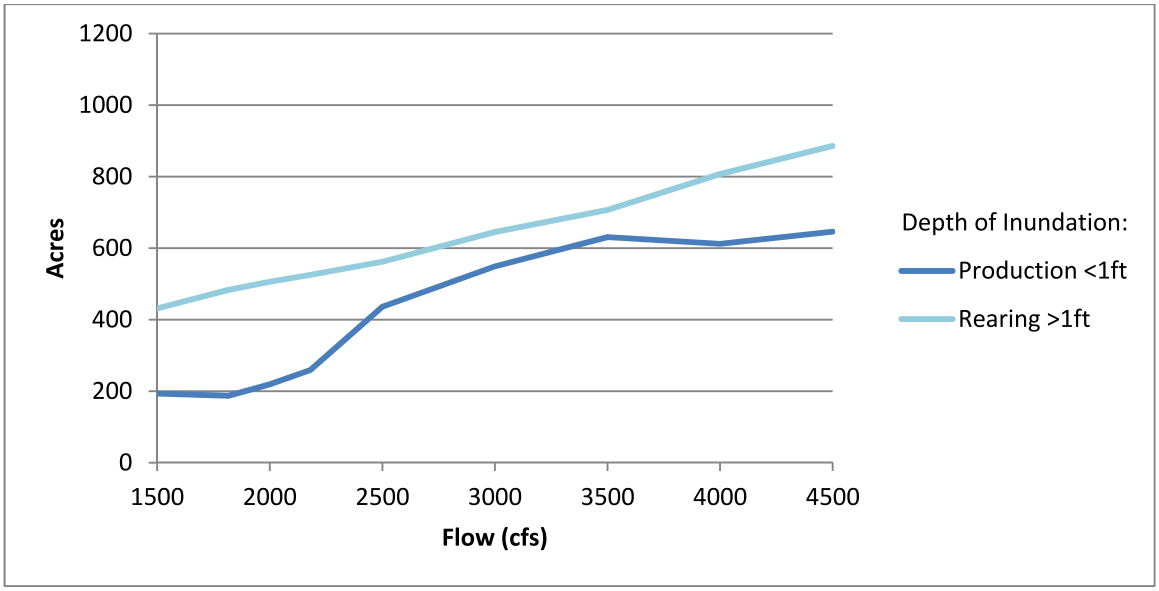
- Temporary bypass facilities around construction areas that meet fish passage criteria.
- Construction in the dry (i.e., not in active flows).
- Phased construction that would allow passage to continue in the channel or in the completed portions of structures while other portions are built.
- Fish rescue and relocation.

2.2.4 Fish Habitat and Passage

The purpose of the floodplain would be to provide riparian and floodplain habitat and support the migration and seasonal rearing of salmonids and other native fishes in Reach 2B. Floodplains would be developed in accordance with the Rearing Habitat Design Objectives. The floodplain has an average width of approximately 4,200 feet and an inundated area of approximately 1,000 acres at 2,500 cfs.

The Project provides floodplain habitat resulting in approximately 440 acres of shallow water habitat for primary production as well as approximately 560 acres of habitat that supports direct rearing at 2,500 cfs. Approximately 44 percent of the floodplain would inundate less than 1 foot deep at 2,500 cfs. The Project also retains approximately 650 acres of shallow water habitat at flows of 4,500 cfs. Figure 9 below presents conceptual inundation areas for primary production and rearing habitats as they vary by flow. Inundation acreages may change during the design process.

In the Compact Bypass channel, floodplain benches with an approximate average width of 100 feet on each side of the low flow portion of the bypass channel are included (see section “Compact Bypass Channel”). Riparian and floodplain habitat would be planted and developed on the benches in the bypass channel to benefit migrating fish and promote a stable channel and sediment transport from Reach 2B to Reach 3.



Source: Reclamation 2015

Figure 9.
Potential Inundation Acreage by Flow

The Project includes several facilities that fish may encounter or need to pass to migrate between Reach 3 and Reach 2B (from downstream to upstream):

- Two in-channel grade control structure rock ramps in the Compact Bypass.
- A bifurcation control structure at the upstream end of the Compact Bypass with fish passage facility.
- The San Joaquin River control structure at the Chowchilla Bifurcation Structure with a fish passage facility.

Each structure would be designed to perform according to the fish passage design criteria. In addition, the channel and floodplain incorporate riparian plantings to provide cover, woody material, and velocity variability, while the design footprint allows sufficient space to incorporate channel structure variability during detailed design, all of which may help to reduce stress and predation.

The Project does not include a fish barrier at the downstream end of the Compact Bypass to keep fish from migrating upstream of the Compact Bypass in Reach 3 toward the base of Mendota Dam.

2.2.5 Floodplain and Riparian Habitat

The Project includes a mixture of active and passive riparian and floodplain habitat restoration and compatible agricultural activities in the floodplain. Active restoration planting of native riparian species would occur along both banks of the low flow channel of the river up to 450 feet from the bank, and would be irrigated with a planting density of approximately 545 plants per acre. In accordance with the Rearing Habitat Design Objectives, it would include native species that would provide shade and reduce air temperatures to help minimize water temperatures, provide large woody debris and organic matter needed to provide habitat and food, and help stabilize the low-flow channel. The irrigated area would include 16-foot spacing between irrigation lines for equipment access and 5-foot spacing along irrigation lines to maximize density. Forbs and grasses would be planted as plugs or transplants in between irrigation lines in order to encourage structural diversity. Some areas may be passively revegetated by creating riparian establishment areas that provide a riparian seed bank of native species. The remaining areas would be seeded with native grasses and forbs to minimize erosion and to help control invasive species. These upland areas would be broadcast seeded or drilled with incorporation, as necessary. Active revegetation activities would likely include a combination of seeding, transplanting, and pole/live stake plantings. Plantings may be designed as either clusters of trees and shrubs with larger areas of seeded grasses and forbs or as dense forests. Spacing and alignment of plantings would take into account species growth patterns, potential equipment access needs for monitoring and maintenance, and desired future stand development. Passive restoration would occur in areas that rely on Restoration Flows for additional vegetation recruitment. Natural riparian recruitment (passive restoration) would promote continual habitat succession, particularly in areas where sediment is deposited or vegetation is removed by natural processes. Table 2 lists the species that are likely to be planted or seeded during active restoration, and is draft and subject to change. Emergent wetlands and water tolerant woody species of riparian scrub would be selected for development within the main channel, woody shrubs and trees with an herbaceous understory would be selected for development along the main river channel banks, and bands of other habitat types (e.g., grasses) would be selected for development at higher elevations along the channel corridor. Active vegetation restoration would occur following construction and these areas would be irrigated and managed as necessary during the establishment period. Phased implementation of active vegetation restoration at strategic locations could occur concurrently with phased implementation of construction and physical infrastructure.

Agricultural practices (e.g., annual crops, pasture, or floodplain-compatible permanent crops) could occur on the floodplain in previous agricultural areas outside of State-owned and public trust lands. Growers would be required to leave cover on the ground and would be required to develop and implement a Water Quality Plan, approved by Reclamation, to meet current water quality standards for aquatic resources and coldwater fisheries, as well as meeting the specific needs for anadromous fishes in adjacent and downstream areas. If grazing occurs the lessee would be required to develop and implement a Grazing Plan, to be approved by Reclamation, in addition to the Water Quality Plan.

Table 2.
Potential Species for Revegetation

Common Name	Scientific Name	Vegetation Type
Riparian Shrub and Wetland Areas (0 to 2 feet above summer baseflow elevations)		
Fremont cottonwood	*Populus fremontii*	Tree
Gooding's willow	*Salix gooddingii*	Tree
box elder	*Acer negundo*	Tree
Oregon ash	*Fraxinus latifolia*	Tree
red willow	*Salix laevigata*	Tree
yerba mansa	*Anemopsis californica*	Forb
common buttonbrush	*Cephalanthus occidentalis*	Shrub
baltic rush	*Juncus balticus*	Tule
California blackberry	*Rubus ursinus*	Shrub
sandbar willow	*Salix exigua*	Shrub
arroyo willow	*Salix lasiolepis*	Shrub
shining willow	*Salix lucida* ssp. *Lasiandra*	Tree
blue elderberry	*Sambucus nigra* ssp. *caerulea*	Shrub
meadow barley	*Hordeum brachyantherum*	Grass
Creeping wildrye	*Elymus triticoides*	Grass
dwarf barley	*Hordeum depressum*	Grass
Douglas' sagewort	*Artemisia douglasiana*	Forb
Great Valley gumweed	*Grindelia camporum*	Forb
Western goldenrod	*Euthamia occidentalis*	Forb
meadow barley	*Hordeum brachyantherum*	Grass
Creeping wildrye	*Elymus triticoides*	Grass
dwarf barley	*Hordeum depressum*	Grass
Dense Riparian Areas (2 to 8 feet above summer baseflow elevations)		
meadow barley	*Hordeum brachyantherum*	Grass
Creeping wildrye	*Elymus triticoides*	Grass
dwarf barley	*Hordeum depressum*	Grass
Douglas' sagewort	*Artemisia douglasiana*	Forb
Great Valley gumweed	*Grindelia camporum*	Forb
Western goldenrod	*Euthamia occidentalis*	Forb
meadow barley	*Hordeum brachyantherum*	Grass
creeping wildrye	*Elymus triticoides*	Grass
red willow	*Salix laevigata*	Tree
shining willow	*Salix lasiandra* var. *lasiandra*	Tree
arroyo willow	*Salix lasiolepis*	Shrub
box elder	*Acer negundo*	Tree
narrow-leafed milkweed	*Asclepias fascicularis*	Herb
coyote brush	*Baccharis pilularis*	Shrub
buttonbush	*Cephalanthus occidentalis*	Shrub
blue wildrye	*Elymus glaucus*	Grass
valley oak	*Quercus lobata*	Tree
golden currant	*Ribes aureum*	Shrub
California wildrose	*Rosa californica*	Shrub
California blackberry	*Rubus ursinus*	Shrub

Table 2.
Potential Species for Revegetation

Common Name	Scientific Name	Vegetation Type
Gooding's willow	*Salix gooddingii*	Tree
blue elderberry	*Sambucus nigra* ssp. *caerulea*	Shrub
Upland Areas (greater than 8 feet above summer baseflow elevations)		
creeping wildrye	*Elymus triticoides*	Grass
California wildrose	*Rosa californica*	shrub
narrow-leafed milkweed	*Asclepias fascicularis*	Forb
valley oak	*Quercus lobata*	Tree
golden currant	*Ribes aureum*	shrub
quail bush	*Atriplex lentiformis*	Forb
western goldenrod	*Euthamia occidentalis*	Forb
small fescue	*Festuca microstachys*	Grass
purple needlegrass	*Stipa pulchra*	Grass
yarrow	*Achillea millefolium*	Forb
Spanish lotus	*Acmispon americanus* var. *americanus*	Forb
Great Valley gumweed	*Grindelia camporum*	Forb
telegraph weed	*Heterotheca grandiflora*	Forb
tomcat clover	*Trifolium willdenovii*	Forb

Existing Native Vegetation Protection

The existing native vegetation in the Project area designated to remain would be temporarily fenced with orange snow fencing (or equivalent) to prevent entry, driving, parking, or storing equipment or material within these areas during construction. Existing vegetation would be left in place or only minimally trimmed to facilitate access and work at the site. The existing soil is an ideal growing medium for all the desired native plants. In order to maximize plant growth and planting success, existing soil and topsoil would be preserved, and in areas where excavation is required, would be stockpiled to later place on top of the excavated bypass channel for planting. If the soil contains invasive non-native seed or fragmented stems and rhizomes, it would not be preserved. Disturbance during construction to existing vegetation would be minimized to the maximum practicable extent.

Invasive Species Control

Invasive, non-native species would be removed from the Project area during the installation, plant establishment and maintenance periods. Invasive species management would consist of removal of the most invasive non-native species within the reach such as giant reed grass (*Arundo donax*), perennial pepperweed (*Lepidium latifolium*) and poison hemlock (*Conium maculatum*). Invasive species management would also include removal of other invasive species that are currently found in upstream reaches and may eventually colonize in the Project area such as red sesbania (*Sesbania punicea*), salt cedar (*Tamarix species*), and Chinese tallow (*Sapium sebiferum*). Invasive plant removal techniques may include mechanical removal, root excavation, hand pulling, mowing, disking, controlled burning, grazing, aquatic-safe herbicides, or a combination of techniques as appropriate.

The SJRRP has an existing invasive species management plan, and completed the *Invasive Vegetation Monitoring and Management Environmental Assessment* in 2012 that describes the methods that would be followed for Reach 2B invasive species removal. Details are provided in Section 2.2 of the Environmental Assessment (SJRRP 2012a).

Temporary Irrigation System and Water Supply

Proposed plantings that are wetland species or borderline wetland species would need regular aboveground irrigation (typically April through October) during their establishment period (typically 3 to 5 years depending on rainfall conditions and the plants' growth rates and vigor). An extensive temporary aboveground irrigation system, such as aerial spray, would provide water for the plants several times a week during the hot months of the year. If an aerial spray irrigation system is installed, the irrigation distribution piping would be installed aboveground and anchored to the ground so that it would not be damaged during high flows inundating the floodplain. If an aerial spray system is used, sprinkler heads would likely be installed on braced standpipes so that their irrigation stream would not be blocked or diverted by growing vegetation. The irrigation system would be disassembled and removed at the end of the establishment period.

The Program would pursue options for irrigation water supply, including groundwater wells or water pumped from the river with portable, skid-mounted, diesel- or gas-powered pumps and stored in tanks. Additionally, purchases from willing sellers may be required to withdraw water from the river or other nearby water sources (e.g., Mendota Pool). If water is pumped from the river, the amount of water diverted would be controlled so that river water temperatures do not increase and passage for salmonids is not impaired. The diversion from the river would also be screened if necessary to prevent entraining juvenile salmonids.

Maintenance and Monitoring

Maintenance and monitoring would be conducted following revegetation for 10 years, yearly for the first 3 years, every other year until year 7, and a final assessment at year 10. Monitoring activities include monitoring of the installed plants for drought stress and overwatering, identification of competitive, invasive, non-native species for removal, identification of diseased, dead and washed-out plants, irrigation system function, and identification of trash and debris for removal. Maintenance activities would include controlling invasive plant species, mitigating animal damage, irrigation, replacement of diseased, dead, or washed-out plants, irrigation system maintenance, and removal of trash and debris. Management of invasive species would ensure that the desirable vegetation dominates the landscape and provides habitat diversity, productivity, and sustainability. Animal damage to newly planted or germinated vegetation could be alleviated with screens, aquatic-safe chemical deterrents, or other exclusion methods.

Temporary irrigation of wetland and riparian areas during establishment, especially if precipitation is below normal, would facilitate root system development into the alluvium groundwater. Irrigation infrastructure would need to be installed and remain in place for at least 3 years. The irrigation system would be used each year on a biweekly to daily basis during the hot part of the growing season. The landscape contractor would be required to regularly check the integrity of the system and make sure that system is not clogged or damaged. Upland areas would be seeded in the fall before the winter precipitation season, and it is likely that these areas would become established to an acceptable level after one season of normal precipitation. (There may be more than one active revegetation effort required to establish a dense riparian corridor necessary to naturally stabilize the Compact Bypass channel.) Removal of trash and debris from the restoration areas on both sides of the river would be performed on an as-needed basis for the duration of the entire monitoring period. Monitoring is anticipated in years 1, 2, 3, 5, 7, and 10 after planting. After 10 years of monitoring and replacement as necessary, vegetation would be established.

Long-Term Management

While it is not anticipated that major management actions would be needed, the key objective of management would be to monitor and identify any environmental issues that arise, and use adaptive management to determine what actions would be most appropriate to correct these issues.

The general management approach to the long-term maintenance of the floodplain areas would be to maintain quality habitat for each natural resource, with on-going monitoring and maintenance of key environmental characteristics of the entire floodplain area within the reach. An adaptive management approach would be used to incorporate changes to management practices, including corrective actions as determined to be appropriate by Reclamation and/or the California State Lands Commission. Adaptive management includes those activities necessary to address the effects of climate change, fire, flood, or other natural events, force majeure, etc.

The expected long-term management needs (and activities necessary to maintain any on-site mitigation sites) would be:

- Resource specific long-term maintenance activities and other general maintenance activities such as exotic species elimination, grazing management, clean-up and trash removal,
- Infrastructure management such as gate, fence, road, culvert, signage and drainage-feature repair, and
- Other maintenance activities necessary to maintain the riparian and floodplain habitat quality.

These activities are expected to continue for the life of the Project.

2.2.6 Water Deliveries

The Project includes a diversion at the head of the Compact Bypass – the Mendota Pool Control Structure – for making up to 2,500 cfs in water deliveries from the San Joaquin River to Mendota Pool. This diversion would directly deliver water from the river to Mendota Pool without the need for a canal. Water deliveries to the Pool would include diversion of Friant Dam releases that are meant to satisfy the Exchange Contract as well as diversion of San Joaquin River flood flows up to 2,500 cfs if there is demand in Mendota Pool.

When water deliveries occur, the gates at the Compact Bypass bifurcation structure would be manipulated to control flows into the Compact Bypass and allow flows into Mendota Pool. Since the Mendota Pool operating elevation is several feet higher than the bottom of the Compact Bypass channel, operation of the gates would include backwatering a portion of the San Joaquin River upstream of the Compact Bypass bifurcation structure. The extent of the backwater is anticipated to be similar to the extent of the Mendota Pool backwater under existing conditions (i.e., upstream to approximately the existing San Mateo Avenue crossing). Up-migrating fish passage from the Compact Bypass into Reach 2B would occur through the Compact Bypass fish passage facility during water deliveries. Sufficient flow to support adult and juvenile fish passage through the Compact Bypass fish passage facility would be maintained during water delivery operations during fish migration periods.

2.2.7 Levees

Set-back levees would be required along the Project area to contain Restoration Flows. While the height and footprint of the levees vary according to their location along the channel and the ground elevation, the capacity, freeboard, and cross-section would be consistent. Localized backwater and redirection effects at Project structures would be considered during design of levee heights. Levees would be designed to maintain at least 3 feet of freeboard on the levees at 4,500 cfs. Levee design would be based on the U.S. Army Corps of Engineers (Corps) *Engineer Manual 1110-2-1913-Design and Construction of Levees* guidelines (Corps 2000) and *Engineer Technical Letter 1110-2-583 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures* (Corps 2014). The design includes seepage control measures, maintenance roads, and inspection and drainage trenches to direct off-site drainage where required.

Levee alignments maintain a 300-foot buffer zone, where appropriate, between the levee and river channel to avoid impact to levees over time due to potential channel migration. In areas where a minimum 300-foot buffer zone between the main river channel and levee cannot be maintained, bank revetment would be incorporated in the design.

New levees would be designed to have sideslopes of 3 horizontal to 1 vertical (3H:1V) on the waterside and landside. A maintenance road and surface drainage ditch would also be included. Surface drainage ditches would only be intended to capture and direct runoff; they are not intended to address groundwater seepage (i.e., water going underneath the levee) or through-levee seepage (i.e., water going through the levee). By following the Corps standards, levees would either have a seepage cutoff wall or would have an inspection trench. Seepage cutoff walls would be constructed on levee segments on the north bypass, south bypass, and north Reach 2B levees to the high point of the Columbia Canal to inhibit groundwater seepage and through-levee seepage during a flood event. Seepage cutoff walls would be comprised of water, cement, and bentonite mixed together before being piped to levee segments using a big stick excavator to install a 3-foot-wide and approximately 28-foot-tall slurry wall. The slurry wall would be 8 feet above the ground and 20 feet below the ground. The above-ground portion would be comprised of 3 feet of freeboard and 5 feet of subsidence bentonite slurry cutoff wall. The below-ground portion would include a 15- to 20-foot-tall bentonite slurry cutoff wall.

Although cement bentonite is non-toxic, benthic invertebrates, aquatic plants, and fish and their eggs can be smothered by the fine particles if bentonite is discharged into waterways. Therefore, the mixing area would be isolated in upland areas away from the San Joaquin River. Additional data collection and analysis would be required to verify the groundwater conductivity rates of the *in situ* and borrow soils and to finalize the design of seepage control measures.

The levee alignments shown on the plan views of the Project may be adjusted during final design. Adjustments may be made for several reasons, including to improve flow conditions on the floodplain, to improve habitat conditions on the floodplain, to reduce potential erosion, to accommodate adverse soil conditions, and to avoid existing infrastructure among others. The final levee alignments would be within the impact areas evaluated in this document.

2.2.8 Seepage Control Measures

Seepage of river water through or under levees is a concern for levee integrity and adjacent land uses. Through-seepage, water that seeps laterally through the levee section, would be addressed through proper levee design and construction (e.g., selection of low porosity materials and proper compaction). Under-seepage, water that seeps laterally by travelling under the levee section, is primarily controlled by the native soils beneath the levee and seepage control measures would be included where native soils do not provide sufficient control. Seepage control measures would be included, as necessary, in the Project in areas where under-seepage is likely to affect adjacent land uses. Seepage control measures could include: cut-off walls, interceptor drains or ditches, seepage wells, seepage berms, seepage easements and other measures that can be implemented within the Project area.[1]

2.2.9 Borrow

Borrow material would primarily be required for the construction of the levees, but it may also be used in the construction of other structures for foundation or backfill material. Levees may be constructed entirely of local borrow material, a mix of local and imported borrow material, or just imported borrow material. Geotechnical investigations to date indicate that local borrow may be sufficient, so it is assumed that nearly all levee

[1] A cut-off wall is a construction technique to reinforce areas of soft earth that are near open water or a high groundwater table with a mixture of soil, bentonite, and cement. Interceptor drains are buried perforated pipes and interceptor ditches are surface ditches, both of which intercept groundwater and redirect it to a discharge point. Because the drains and ditches have lower resistance to flow, the groundwater table can be kept artificially low in areas near the pipe or ditch. The discharge point could include a lift pump to move drained water over the levees, or it could be discharged directly to a surface water body (e.g., agricultural canal). Seepage wells are groundwater wells that are used to pump and draw down the water table where seepage is occurring. Seepage berms are berms placed on the landside of a levee to add additional weight and width to the levee to counteract seepage.

fill would come from local borrow sites. Topsoil from local borrow areas would be stockpiled for reuse at the borrow site or within the Project area.

The locations of borrow areas are dependent on the locations of suitable materials. To the extent that suitable materials and the locations for floodplain grading coincide, borrow from those areas is preferred. Borrow from within the Project levees would be designed to be compatible with native fish habitat and uses by either reconnecting to the river channel or by restoring to an appropriate elevation to prevent stranding.

It is estimated that up to 350 acres of land total would be needed for borrow areas. This includes borrow locations inside and outside the Project levees (identified as Potential Borrow Area on Figures 2 and 3). Borrow areas would avoid sensitive biological resources to the extent practicable. Borrow areas would also avoid permanent crops outside of the Project levees.

2.2.10 Levee and Structure Protection

The Project generally provides a minimum 300-foot buffer between the existing channel and the proposed levee, where appropriate and feasible. For locations where the 300-foot buffer was not included, erosion protection for the levee in the form of revetment would be included. The revetment would be riprap material covered by soil and then planted to provide a vegetated surface. However, softer approaches, such as bioengineering or dense planting, may be considered during design depending on velocities and scour potential. Locations that require revetment include areas where the 300-foot buffer was not included due to the proximity of existing infrastructure, near the proposed structures, and along river bends less than 300 feet from the levee in areas that have the potential to erode, as determined in the design process.

2.2.11 Channel Bank Protection

The Project could include riparian vegetation, rock vanes, woody materials, revetment, or other measures designed to protect channel banks from erosion. Bank protection measures would be installed in locations susceptible to and likely to experience bank erosion.

2.2.12 Removal of Existing Levees

Removal of portions of the existing levees is included and designed to expand the inundation area of the floodplain out to the proposed levees and improve connectivity between the river channel and proposed floodplain. The locations of existing levee removal would be based upon the hydraulic performance of the channel and floodplain. In certain locations, however, highly desirable existing vegetation (native and sensitive vegetation communities that can serve as seed banks for future vegetation communities) can be found on the existing levees. Where hydraulic performance and connectivity of the floodplain would not be negatively affected, portions of the existing levees with highly desirable vegetation would remain in place. Materials that are removed from the existing levees would likely be reused within the Project area.

2.2.13 Floodplain and Channel Grading

Floodplain and channel grading would be included with the Project. Floodplain and channel grading would include any or all of the following at locations to be determined during design:

- Creating high-flow channels through the floodplain to increase the inundation extent at lower flows.
- Connecting low-lying areas on the floodplain to the river to prevent stranding.
- Removing high areas where flow connectivity would be impeded (e.g., farm road grades).
- Excavating floodplain benches adjacent to the river channel to increase the frequency of inundation.
- Creating greater inundation depth diversity on the floodplain.
- Excavating channels in portions of the Project area to tie into existing elevations upstream and downstream of the Project or to create desirable sediment transport conditions.

Floodplain and channel grading can provide benefits to salmon and other native fish by allowing inundation to occur at lower flows, by distributing suitable rearing habitats further into the floodplain, by connecting rearing habitat to primary production areas (shallow water habitat), by providing escape routes during receding flows, and by confining flows to a deeper, narrower channel to limit temperature increases.

Figures 10 and 11 provide an example of how various floodplain grading approaches can be used to expand inundation on the floodplain. The Existing Channel graphic shows an example of how inundation would occur without floodplain grading. The Lowered Floodplain example shows an example of how floodplain benches, lowered areas to either side of the channel, could be used to inundate floodplain areas at lesser flows. This graphic also shows how lowered floodplains could affect inundation at moderate flows. The High Flow Channels graphic shows an example of how high flow channels, side channels that initiate at larger flows than the main channel, could be used to expand floodplain inundation.

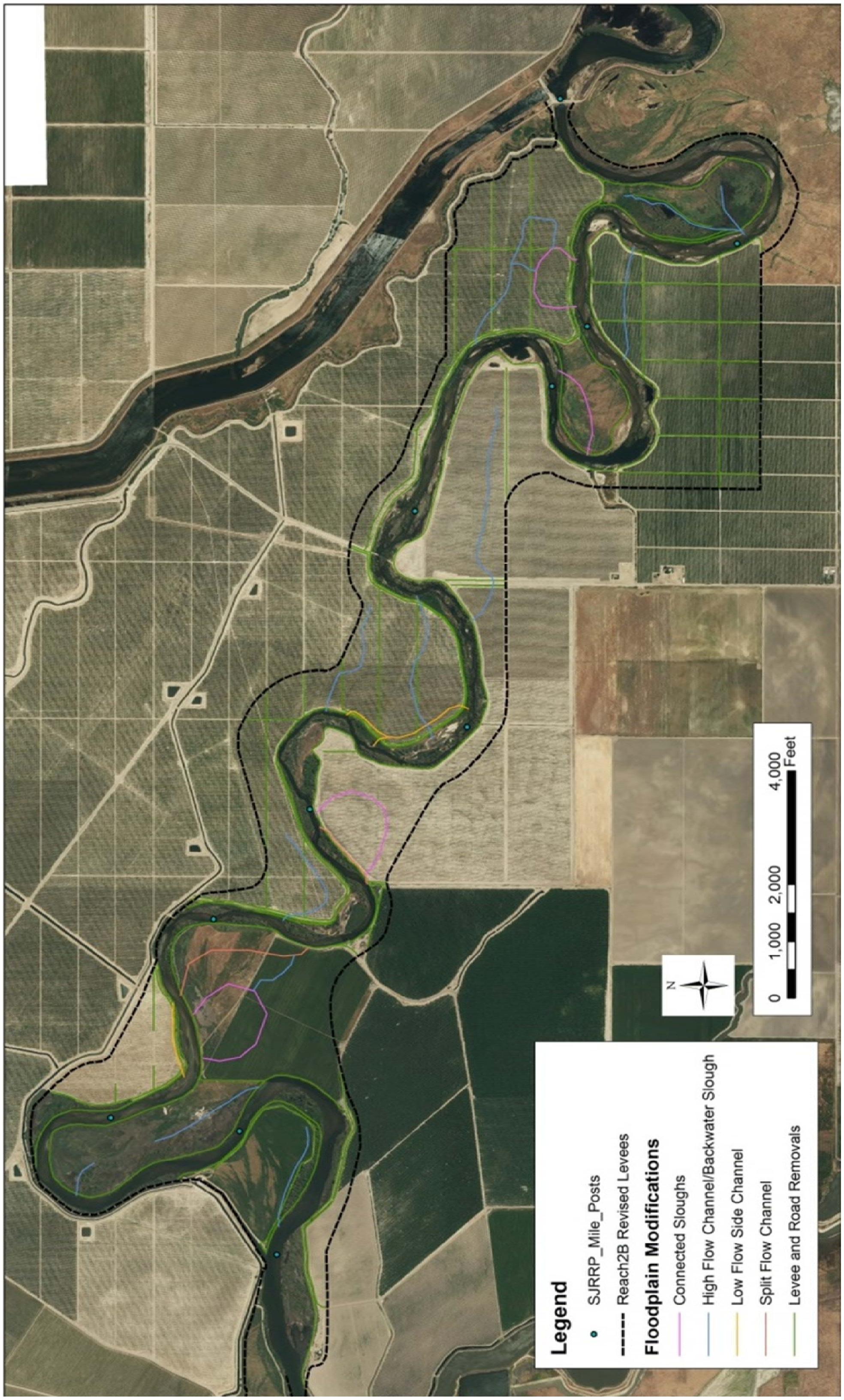


Figure 10.
Example Floodplain Grading Approach – Plan View

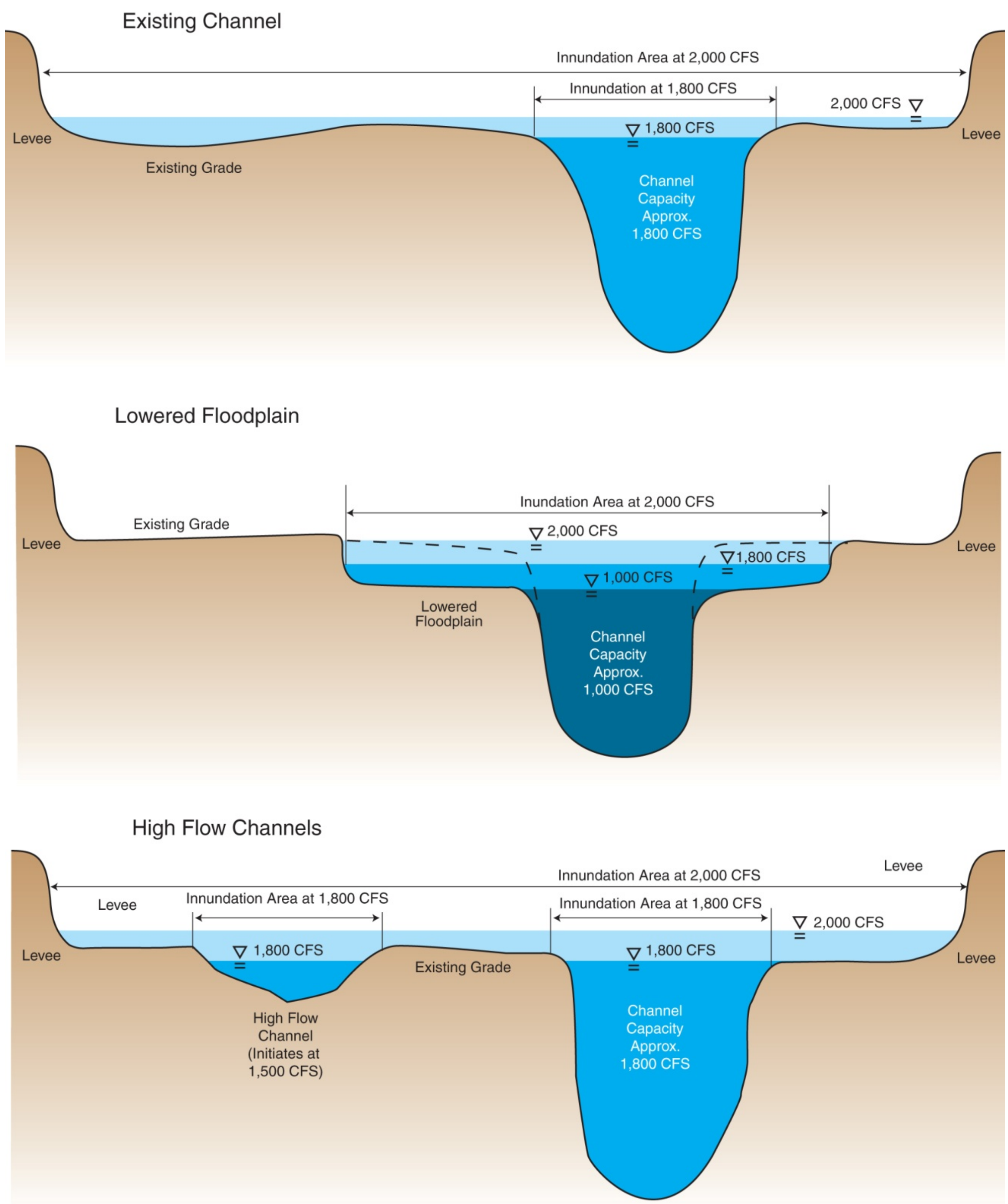


Figure 11.
Example Floodplain Grading Approaches – Cross Section

2.2.14 Geotechnical Investigations

Geotechnical investigations are required to evaluate soil suitability for final design of the Project, and may be required to conduct monitoring of seepage after construction of the Project. Geotechnical investigations may include hydraulic conductivity tests, soil sampling, soil salinity testing, installation of monitoring wells, back-hoe pits, Standard Penetration Tests, Cone Penetrometer Tests, or other forms of geotechnical investigations. All of these investigations are included as part of this Project, may occur anywhere within the Project area, and at any time during the life of the project.

2.2.15 Surveys

Biological, cultural resources, and elevation surveys are required to complete final design of the Project and conduct post-project monitoring. Surveys may include trapping of fish species including fall-run Chinook salmon, spring-run Chinook salmon, and steelhead to evaluate constructed items, monitoring of vegetation on transects or plots, visual, habitat assessment, reconnaissance, and protocol level endangered species surveys, vegetation mapping, bathymetry surveys, elevation surveys, digging of cultural resource inspection trenches, water quality sampling, or any other surveys required for environmental compliance, permitting, design data collection, or monitoring activities. All of these investigations are included as part of this Project, may occur anywhere within the Project area, and at any time during the life of the Project

2.2.16 Infrastructure for Fish Monitoring

The designs for control structures and fish passage facilities include security fences and gates, mounting hardware, and electrical supply in order to conduct fish monitoring activities. Fish monitoring activities are expected to include connections for PIT (passive integrated transponder) tag arrays at the Compact Bypass Control Structure and the San Joaquin River control structure of the Chowchilla Bifurcation Structure and Didson camera mounts at the edges of the Compact Bypass Control Structure and San Joaquin River control structure, as well as a vault and connection for a visual fish imaging technology in the Compact Bypass fish ladder. Acoustic tagging receivers can be placed at various locations within the reach and anchor points would be provided at structures, where appropriate. Construction, operations, and maintenance of the fish monitoring infrastructure are included as part of this Project. The fish monitoring activities themselves are not included in this Project, and will be addressed in subsequent environmental analysis, as appropriate.

2.2.17 Existing Infrastructure Relocations or Floodproofing

Existing infrastructure (see Figure 12) such as groundwater wells, pumps, electrical and gas distribution lines, water pipelines, and canals located in the Project area would require relocation, retrofitting, or floodproofing to protect the structures from future Restoration Flows and increased floodplain area. Floodproofing could include extending the levees, raising the ground surface, and construction of a sheet pile wall or slurry wall. Although the relocations, retrofits, and floodproofing are included as part of the Project, the actual relocation, retrofit, or floodproofing work may be performed by others. As a result of the Project, some existing infrastructure may be unnecessary in the future (e.g., power lines that service pumps relocated to outside the Project area). In these cases, infrastructure may be demolished or abandoned in place.

Specific plans for relocations, where known, are identified below:

- Natural gas pipelines would be buried lower in the soil column to avoid interference with project activities.
- Water pipelines would be either buried lower in the soil column or relocated outside of levees.
- City of Mendota's three groundwater wells would remain in place. Two of them are outside of the levee alignments and would remain unaffected. The third well is immediately adjacent to the San Joaquin River and would be floodproofed, with the adjacent levee extending to protect the well.
- The Mowry Bridge, which holds the city of Mendota's water pipeline, would be replaced for construction access and the water pipeline would be replaced across the new bridge.

Electrical and Gas Distribution

Approximately 48,500 feet of electrical distribution lines and 11,000 feet of gas distribution lines were identified for possible relocation. Information from Pacific Gas & Electric was available for portions of the area in Geographic Information System (GIS) shapefile format and was supplemented by field data. At the current level of design, it was assumed that a portion of the existing electrical and gas distribution lines found within the Project area would need to be replaced and/or excavated and buried lower in the soil column. Three gas pipelines are buried under the San Joaquin River in this reach. They would need to be re-buried deeper or floodproofed. This may involve trenching and excavation along the pipeline length, within and outside of the future floodplain area, to re-bury it deeper in the soil column below any potential impacts from floodplain grading.

Canals and Drains

Approximately 31,500 feet of canals were identified for possible relocation. On-farm canals and drains visible on the LiDAR imagery (CVFED 2009) and identified during on-site field meetings with landowners were quantified. No canals or drains outside the Project footprint have yet been identified for redesign. Some portions of canals and drains could be discontinued in the future; the extent of discontinued and replaced canals would be considered during landowner negotiations. No subsurface drains were able to be quantified; however, some are believed to exist within the area.

Lift Pumps

Ten lift pumps were identified for possible relocation. Lift pumps visible on the LiDAR imagery (CVFED 2009) or noted in the CalFish Passage Assessment Database (CalFish 2014) were assumed to require relocation to new facilities on the edge of the proposed levees. A pilot channel dug from the low flow river channel to the intake of the relocated pumps was also assumed. Locations in the CalFish Passage Assessment database were confirmed using the LiDAR imagery when possible.

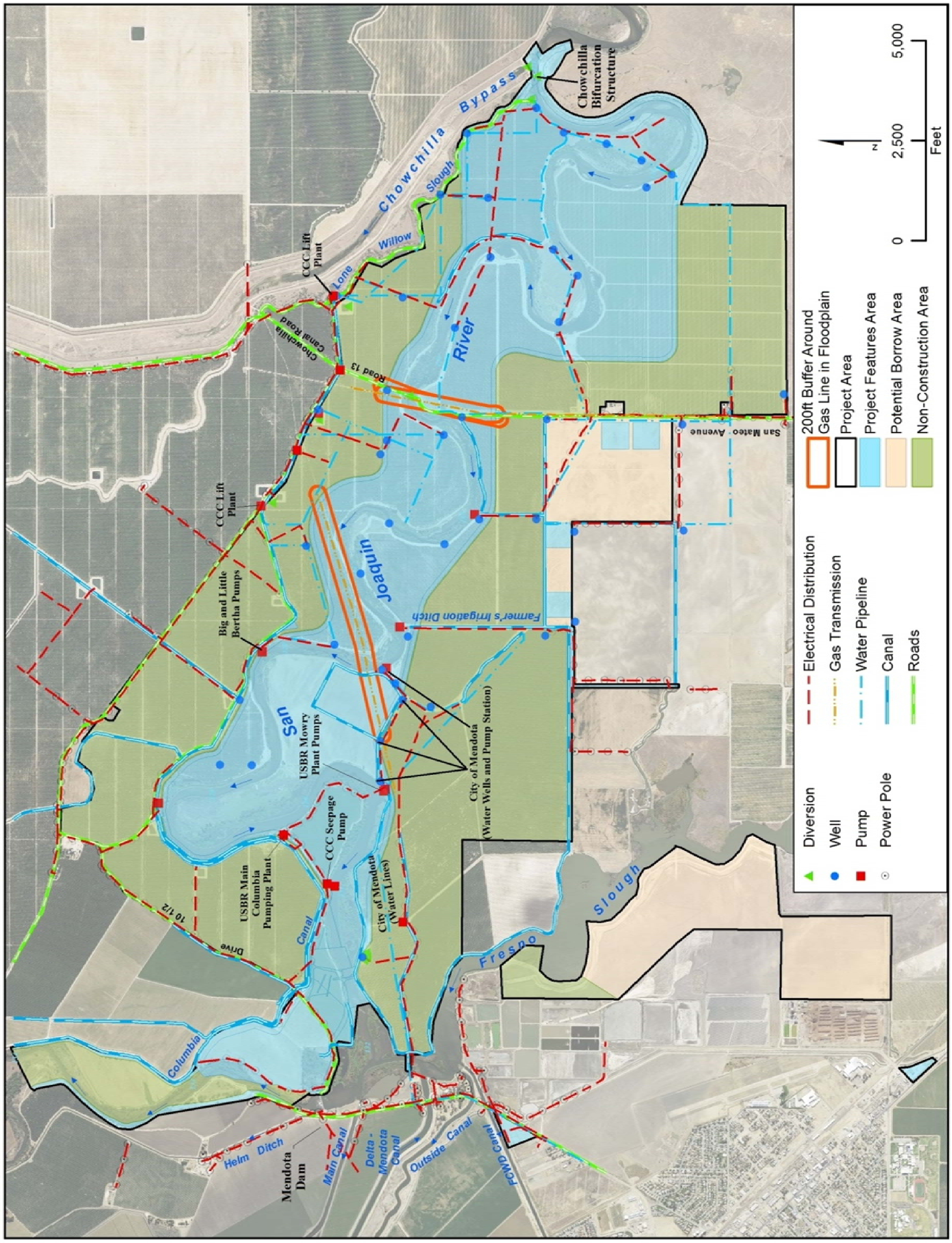


Figure 12.
Existing Infrastructure in the Project Area

Groundwater Wells

Thirty-two groundwater wells were identified for possible floodproofing or relocation, including the city of Mendota groundwater wells. Wells were identified within the area using aerial photography. During design, the DWR wells database would be consulted to find abandoned wells that have not been destroyed, so that these old wells could be filled in to prevent a flood water conduit to the groundwater. A formal well canvas would also be conducted. Floodproofed wells would be provided with year-round vehicular access via a raised roadbed across the floodplain. The roadbed could include multiple culverts to support floodplain connectivity, depending on the length of the access road and its effect on floodplain flows. Wells relocated by the Project would provide equal utility. Wells taken out of service by the Project would be abandoned in accordance with U.S. Environmental Protection Agency, DWR and/or local regulations.

The levee alignment has been designed so that two of the city of Mendota’s three groundwater wells would be outside of the levees and floodplain area, and unaffected by the project. The remaining well is inside the levee and right next to the river, and would be floodproofed. The setback levee would be extended around the groundwater well to allow access and prevent flooding.

Regulating Reservoirs

A number of irrigation regulating reservoirs were identified for possible relocation. Reservoirs were assumed to be a typical size, contain one lift pump, and half of the reservoir located below the surrounding grade and half above the surrounding grade.

Oil and Gas Wells

Two closed or active oil and gas wells have been identified within the Project area for potential closure, relocation, or buyout. If active oil and gas wells cannot be avoided, the destruction or closure of those wells would be conducted in accordance with the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources regulations.

Other Utilities

Other infrastructure was identified within the impacted areas. These other facilities include high voltage transmission lines and water pipelines. High voltage transmission lines are assumed to be high enough to not be impacted. Water pipelines were quantified from existing maps and discussions with landowners. Water pipelines may be relocated or abandoned depending on their future use requirements. The city of Mendota has a water pipeline from their three groundwater wells that crosses Mowry Bridge. This pipeline may need to be modified as the setback levee would cross it, and Mowry Bridge would likely need replacement for construction access. Service line crossings (e.g., gas, water, electrical) would be considered during levee design.

2.2.18 Construction Access

Access for vehicles carrying materials, equipment, and personnel to and from the construction area would be provided via several existing roadways in the Project vicinity (see Figure 13). Improvements may be required to upgrade roadways, pavements, and crossings for anticipated construction traffic and loads, provide adequate turning radii and site distances, and to control dust on non-paved roads. Anticipated improvements include:

- Eastside Drive – Approximately 0.6 mile of dirt road starting at Road 10 ½ would likely require overlaying, and the implementation of dust control measures.
- Chowchilla Canal Road/Road 13 – Approximately 0.3 mile of road starting at Eastside Drive would likely require some overlaying and the implementation of dust control measures.
- San Mateo Avenue – Approximately 0.5 mile of gravel and 1.5 miles of oil-dirt road starting at the existing San Joaquin River levees would likely require some overlying and the implementation of dust control measures.
- Bass Avenue Canal Crossings – These crossings may need additional bracing and shoring to ensure that they would be able to support the load of the construction equipment and activities. All the construction equipment on Bass Avenue would be within the legal loads (see note below). This crossing is on the Fresno County replacement list.
- Delta-Mendota Canal Crossing – This crossing may need additional bracing and supports to ensure that it would be able to support the load of the construction equipment activities.
- Mowry Bridge – This bridge would need replacement as it is currently condemned due to beaver activity. It would provide convenient access to the site of the Mendota Pool control structure.

Dust control measures for non-paved roads could include the use of water trucks or dust palliative for dust control or gravel placement where necessary. Legal loads would be used on all roads, and once construction is completed, the roads would be returned to the same condition as they were prior to the Project.

2.2.19 Revegetation of Temporary Disturbance Areas

Areas temporarily disturbed during construction would be restored to their previous contours, if feasible, and then seeded with a native vegetation seed mixture to prevent soil erosion. Some areas, such as borrow areas, may not be feasible to restore previous contours, but these areas would be smoothed and seeded. Staging and borrow areas would occur on annual cropland or land purchased for the Project and not on permanent cropland outside of the Project levees.

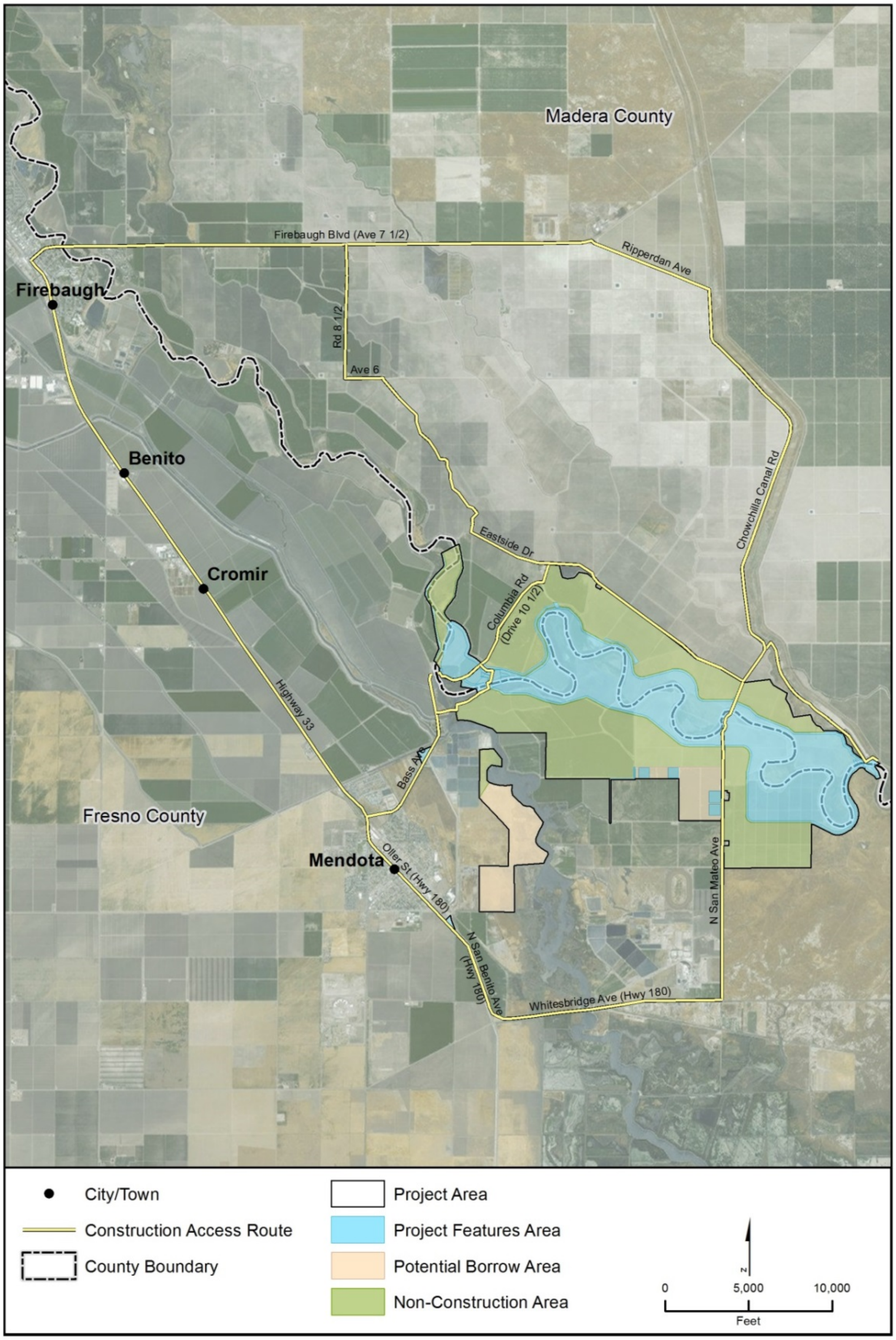


Figure 13.
Construction Access Routes

2.2.20 Operations and Maintenance

The Project includes long-term operations and maintenance of the proposed facilities and features as described below.

Maintenance

Levees would require maintenance for vegetation management, access roads, levee inspections, levee restoration, rodent control, minor structures, encroachment removal, levee patrolling during flood events, and equipment. Levee vegetation management includes equipment to drag or mow the levee banks or aquatic-safe herbicide applications. Maintenance of access roads includes replacing gravel or scraping and filling of ruts to keep the roads in good condition. Levee restoration includes restoring areas with erosion or settlement problems or adding armor. Rodent control includes setting traps with bait and periodically checking the traps. Minor structures maintenance includes repair or replacement of gates, locks or fences. Encroachment removal involves removing illegally dumped materials.

Floodplain maintenance includes vegetation management for invasive species, periodic floodplain and channel shaping to retain capacity and prevent fish stranding, and other floodplain maintenance activities such as debris removal and repair of channel banks and bank protection measures.

~~San Mateo Avenue maintenance includes maintenance when flows overtop the road and annual maintenance to keep the crossing functional and ensure that it can meet fish passage requirements. These maintenance activities include cleaning the culverts of debris or sediment, clearing any debris from the roadway prior to opening after flows have receded, repairing the road sub-base, base, and gravel surfacing, and repairing or replacing minor structures. Minor structures maintenance includes replacing gate locks, painting gates, replacing lost or damaged signage, and lubricating gates.~~

Control structures maintenance includes annual operating maintenance for control gates, lubricating the fittings, greasing and inspecting the motors, replacing parts and equipment, in-channel sediment removal in the structure vicinity, and cleaning the trash rack. Work needed for the radial gates includes inspection of gates and seals and periodic replacement of seals. Work needed for the trash rack includes periodic repair or replacement of components, inspecting for operation, and greasing and inspecting the motors.

~~Fish barrier maintenance is needed to ensure that the barrier is functioning to NMFS standards and capable of passing the required flow. Fish barrier maintenance includes periodic repair or replacement of screens, in-channel sediment removal in the structure vicinity, and debris removal.~~

Fish passage facility maintenance is needed to ensure that the passage facility is functioning to NMFS standards. Depending on the type of fish passage facility built, fish passage facility maintenance could include removing sediment and debris from the facility, in-channel sediment removal in the structure vicinity, inspection of gates and seals and periodic replacement of seals, periodic repair or replacement of weir gates, periodic repair or replacement of supplementary water system components, inspection for operation, greasing and inspecting motors, and replacement of riprap, grouting, boulders, large woody debris, or other “natural” features of the fish passage facility. The facility would be checked annually in years when releases for the San Joaquin River Exchange Contractors are anticipated to verify working condition prior to use.

Seepage control measure maintenance is dependent on the type of measures implemented but could include activities such as periodic sediment removal and ~~channel~~ re-shaping ~~for~~ of ~~interceptor~~ drainage ditches, cleaning or flushing of interceptor drains, repair and replacement of pump parts for seepage wells and lift pumps, and vegetation management, berm restoration, and rodent control for seepage berms. If 15-foot-deep slurry walls are constructed at all setback levees, as expected in the Compact Bypass area, maintenance efforts associated with the seepage control measure is expected to be minimal.

Levee and structure protection maintenance includes repair and restoration of protection measures due to erosion or degradation and vegetation management.

Water diversion canal maintenance includes sediment removal and channel re-shaping.

Maintenance Schedule

All maintenance activities, when possible, would be timed to minimize the impacts to fish. Access and safety concerns, as well as timing of flows, may affect timing of the maintenance activities, but can be scheduled around fish migration.

Maintenance of levees and floodplains with aquatic-safe herbicide treatment would occur sometime between spring and fall and would depend on the plant species that are being treated. Typically the herbicide would be administered prior to the plant going to seed and may need to be sprayed more than once. Disking for vegetation management usually occurs twice within the year; once in early spring after the rainfall season and then again in late summer prior to plants going to seed. Access road and levee restoration work would likely be done in the summer after the rainfall season, and timing and projects would be dependent on environmental clearance for small mammals, nesting birds or burrowing owls, and other wildlife species. Rodent control would likely be done by a pest control advisor and would likely be done in the spring through fall and not during the rainfall season. All levee and floodplain work can be impacted by the presence of nesting birds, so in some areas work may not begin until the nesting birds have fledged or if there is some other biological reason to believe that the maintenance activities would not impact the nesting birds.

Timing of the maintenance of structures within the waterways would depend on the flow hydrograph and forecasted flows, but can typically be expected in the summer/fall after high spring flows have receded. Cleaning of the in-channel structures would typically occur when flows are low enough to allow crews and equipment to enter the river safely to access the structures. San Mateo Avenue may be cleared or repaired earlier for access as soon as flows recede and are not likely to increase for the remainder of the water year. If earlier, this work would only be for road access and would not be located in the channel itself.

Debris that collects on trash racks, screens, ladders, or other fish passage structures would need to be periodically removed but would likely be scheduled based on the operation permits for these structures. Annual maintenance cleaning would be expected after the fish migration, but would need to be timed when flows have receded.

Lubing and annual gate maintenance would likely be in the late summer or early fall prior to winter and spring flows to make sure the structures are operating properly and to provide time for repairs and ordering parts if needed.

Water diversion canals that require maintenance could be isolated from the river system by closing the headgates at the canals which would not impact fish migration.

Operations

There are no operations for levees, floodplains, or levee and structure protection.

San Mateo Avenue operations include closing the gates to the crossing during high flows and reopening once flows have receded.

Control structures operations include operating the motors for the control gates, inspecting and assessing the gates, adjusting the gates for various stages of flows, adding short walls to the stop-log guides after years of subsidence, and running the automatic trash sweep.

Columbia Canal intake structure operations include removal of sediment in the sediment collection basin and running the automatic trash sweep.

Fish barrier operations could occur every day during salmon upmigration for spawning. Operations include visually inspecting screens, verifying flow, clearing obstructions and debris, installing and removing barrier screens, and permitting and regulatory compliance measures.

Fish passage facility operations could occur every day during fish migration. Operations include visually inspecting the facility, verifying flow, clearing obstructions and debris, adjusting the weirs, permitting and regulatory compliance measures, estimating performance (i.e., velocity measurements), fish monitoring, and powering mechanically controlled weirs.

Seepage control measure operations are primarily passive, but seepage well operations would include running the pumps to lower the water table, and interceptor drain and ditch operations could involve running lift pumps.

2.2.21 Monitoring Activities

Monitoring activities would include physical and nonphysical activities within the Project area. Several monitoring components would be covered by the Program's *Physical Monitoring and Management Plan* (PEIS/R pages 2-49 to 2-52, and Appendix D.1, SJRRP 2011b), which provides guidelines for observing conditions as well as adjusting to changes in physical conditions within the Project area. The Program's *Physical Monitoring and Management Plan* consists of multiple component plans, addressing physical conditions such as flow, groundwater seepage, channel capacity, and propagation of native vegetation. Each component plan identifies objectives for the physical conditions within the Project area, and provides guidelines for the monitoring and management of those conditions. The component plans identify potential actions that could be taken to further enhance the achievement of the objectives. Finally, the Plan includes a description of monitoring activities which apply to one or more of the component plans. The component plans include the following monitoring objectives, all of which are identified in the Program's *Physical Monitoring and Management Plan*:

- **Flow –** To ensure compliance with the hydrograph releases in Exhibit B of the Settlement and any other applicable flow releases (e.g., buffer flows) (detail is provided in the Program's *Restoration Flow Guidelines*).
- **Seepage –** To reduce or avoid adverse or undesirable seepage impacts (detail is provided in the Program's *Seepage Management Plan*).
- **Channel capacity –** To maintain flood conveyance capacity (detail is provided in the Program's *Channel Capacity Report*).
- **Native vegetation –** To establish and maintain native riparian habitat.

Project specific components of the monitoring would include addressing effectiveness monitoring of fish screens and fish passage at structures within the Project area. The monitoring objective is the following:

- **Passage and screening effectiveness –** To maintain effective fish passage and fish screening at structures and diversions.

Monitoring activities, as they are described in the Program's *Physical Monitoring and Management Plan*, are guidelines for monitoring and could change during Project implementation. Monitoring activities in Reach 2B could include the following Program-level activities:

- **Flow monitoring –** Flow, cross sections, and surface water stage at gaging stations, and at additional locations during high-flow events.
- **Groundwater level monitoring –** Groundwater elevation in monitoring wells (detail is provided in the Program's *Seepage Management Plan*).
- **Aerial and topographic surveys –** True color aerial photographs and topographic surveys to assess river stage, hydraulic roughness, river width, bed elevation, and vegetation conditions.
- **Vegetation surveys –** Surveys of seed dispersal start and peak times, and native riparian vegetation establishment.
- **Sediment mobilization monitoring –** Sediment mobilization, bar formation, and bank erosion through aerial and topographic surveys of areas with elevated erosion potential (detail is provided in the Program's *Sediment Management Plan*).

Project specific monitoring activities would include the following:

- **Passage and screening effectiveness –** Flow, cross-sections, water surface, and velocity measurements near and within structures that provide passage or screening. Fish counting devices and rotary screw traps to count and measure fish passage and fish size.

2.2.22 Structure Design and Subsidence

All design work would be completed in general accordance with Reclamation Design Standards, applicable design codes, and commonly accepted industry standards. Where design criteria are missing for a specific project element, either Reclamation would be consulted for design specifications or standard engineering practice methods would be employed.

In addition, ground subsidence effects are anticipated to be experienced in the Project area. Based on subsidence data collected from December 2011 to July of 2015, Reclamation is designing this Project for 5 feet of subsidence, which is equal to the current rate for 25 years. In 2042 (25 years from the start of construction of this Project) the Sustainable Groundwater Management Act requires Groundwater Sustainability Agencies to have reached sustainable levels of withdrawal in all State groundwater basins, presumably meaning subsidence would have stopped. Methods to mitigate this anticipated ground subsidence included are additional freeboard on levees, additional height of control structures and intake facilities, and additional stoplogs or concrete walls to maintain the same low flow elevation after years of subsidence on control structures.

2.2.23 Land Acquisition

The approximate amount of additional lands to be acquired to accommodate the floodplain, levees, bypass channel, structures, and borrow was quantified based on parcel data in GIS shapefile format from Fresno and Madera counties. Since remaining portions of parcels that fall outside the Project area may not be as easily utilized by the land owners, the entire parcels were considered, where appropriate. The amount of land acquisition for the Project would be 2,900 acres.

2.2.24 Phased Implementation

The Project may utilize a phased approach to implementation. Phased implementation would involve building selected components of the Project in separate construction phases, allowing Project funding to be secured over time. Currently the bypass channel and associated structures are planned for construction first, followed by the Reach 2B setback levees and floodplain grading. Exact phasing would be developed during the detailed design phase.

2.2.25 Construction Considerations

The total construction timeline for the Project is currently estimated to range approximately from 106 to 157 months (9 to 13 years); opportunities to shorten the overall schedule through construction efficiencies would be studied during the detailed design process.

Soil improvements for possible liquefiable soils may be required to protect proposed structures from damage or failure during an earthquake. All proposed structures would be designed to account for potential liquefaction. Soil improvements could include removing and replacing soils with adequate materials, injecting soil-cement slurry, vibrofloatation, dynamic compaction, structural foundation piles (stone or reinforced concrete), and other techniques.[2]

Flow in the San Joaquin River, operations at the existing Mendota Dam, operations at the Chowchilla Bifurcation Structure, and operation of the existing Columbia Canal must be maintained during construction. The majority of the Compact Bypass channel would be constructed without interruption to the San Joaquin River flow or the Columbia Canal, by conducting the excavation in the dry and constructing the Compact Bypass bifurcation structure last.

The construction of the Mendota Pool control structure across the existing river channel would require removable cofferdams in two phases to facilitate the construction without blocking the flow. If flow is present in the river during the construction period, flow would be diverted around the work area via a temporary diversion pipe or canal and fish passage would be provided. Cofferdams include two rows of braced sheet piling filled with dirt for stability and seepage control. The total height of the cofferdam is assumed to be 24 feet of which 12 feet would be above the channel bed. The control structures to be constructed on dry land (e.g., the Compact Bypass control structure) would not require cofferdams.

Stone slope protection (riprap) would be provided on the upstream and downstream slopes of the control structure embankment including some portions of the side slopes of the channel itself to prevent scouring. Riprap would be placed on bedding over geotextile fabric. Riprap would be filled with soil and planted with native vegetation.

All fish facility structures and pipes with surfaces exposed to fish require additional attention to surface-smoothness.

For construction of the control structures and fish passage facilities, it would be necessary to maintain a minimum flow during construction during fish migration periods; the amount or range of flows during construction has not yet been identified. The construction of the Compact Bypass would be undertaken in the dry. The levee between the Compact Bypass and the Mendota Pool would be one of the first components constructed, as it includes a cement-bentonite wall that would assist in dewatering the rest of the site. This cement-bentonite wall would extend around the Compact Bypass Control Structure site on existing land, providing dewatering for the construction of the structure as well. Soil would remain in the location of the Compact Bypass Control Structure until the entire bypass is graded, levees are constructed, and the bypass is revegetated, at which time the Compact Bypass Control Structure would be constructed. The pilot channel would be excavated when the Mendota Pool Control Structure is complete and flows would start passing through the Compact Bypass.

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[2] Vibrofloatation uses a vibrating probe that penetrates the soil and causes the grain structure to collapse and increase the density of the soil. Dynamic compaction involves dropping a heavy weight onto soil to compact it.

Demolition of the San Mateo Avenue crossing would be timed so that the lesser Restoration Flows (5 to 195 cfs) can be routed around the structure during demolition.

2.2.26 Relocations

Specific plans for relocations, where known, are identified below:

- Natural gas pipelines would be buried lower in the soil column to avoid interference with project activities
- Water pipelines would be either buried lower in the soil column or relocated outside of levees
- City of Mendota's three groundwater wells would remain in place. Two of them are outside of the levee alignments and would remain unaffected. The third well is immediately adjacent to the San Joaquin River and would be floodproofed, with the adjacent levee extending to protect the well.
- The Mowry Bridge, which contains the city of Mendota's water pipeline, would be replaced for construction access and the water pipeline would be replaced across the new bridge

2.2.27 Summary

Table 3 summarizes the levees, relocations, land acquisition, and construction schedule associated with the Project based on design, field, and evaluation criteria data

Table 3.
Levees, Relocations, and Land Acquisition

		Left Levee		Right Levee
Levee Length		8.1 miles		6.8 miles
Average Levee Height		5.6 feet		4.7 feet
Fill Volume		328,600 cubic yards		226,900 cubic yards
Relocations				
Electrical Distribution	48,500 feet	Barn/Shed		1
Gas Transmission	11,000 feet	Facility		1
Water Pipeline	41,000 feet	Groundwater Well		32
Canal	31,500 feet	Lift Pump		10
Culvert	1	Power Pole		162
Diversion	3	Dwelling		2
Land Acquisition and Construction Schedule				
Land Acquisition[1]	2,900 acres			
Time to Build[2]	157 months			

[1] Total acreage includes areas that are sovereign and public trust lands.

[2] Construction timeline does not include the time that would also be needed to complete the National Environmental Policy Act and California Environmental Quality Act documentation process, obtain permits, appraise and acquire land, and perform pre-construction surveys.

2.2.28 Conservation Measures

The Project includes conservation measures based on the Program's Conservation Strategy, developed with the USFWS, NMFS, and DFW, which would be implemented in a manner that is consistent with adopted conservation plans for sensitive species, and for wetland and riparian ecosystems of the Restoration Area. Those measures address all potentially affected Federally-listed and/or State-listed species, and all other species identified by USFWS, NMFS or DFW as candidates, sensitive, or special-status in local or regional plans, policies, or regulations. Table 4~~Table 4~~ presents the elements of the Program's Conservation Strategy as applicable to the Project's NMFS BA. The measures presented here are based on those presented in the PEIS/R.

Table 4.
Conservation Measures for Biological Resources That May Be Affected by Project Actions

Conservation Measure and Identifier	Applicable Habitat and/or Species, and Conservation Measure Description	Regulatory Agency
RHSNC	**Riparian Habitat and Other Sensitive Natural Communities**	
RHSNC-1. Avoid and Minimize Loss of Riparian Habitat and Other Sensitive Natural Communities	Biological surveys have been conducted to identify, map, and quantify riparian and other sensitive habitats in potential construction areas. See Section 6.3.3 of the EIS/R. Construction activities will be avoided in areas containing sensitive natural communities, as appropriate.	DFW
RHSNC-2. Compensate for Loss of Riparian Habitat and Other Sensitive Natural Communities	The Riparian Habitat Mitigation and Monitoring Plan for the SJRRP is being developed and implemented in coordination with DFW. Credits for increased acreage or improved ecological function or riparian and wetland habitats resulting from the implementation of SJRRP actions will be applied as compensatory mitigation before additional compensatory measures are required. If losses of other sensitive natural communities (e.g., recognized as sensitive by CNDDB, but not protected under other regulations or policies) would not be offset by the benefits of the SJRRP, then additional compensation will be provided through creating, restoring, or preserving in perpetuity in-kind communities at a sufficient ratio for no net loss of habitat function or acreage. The appropriate ratio will be determined in coordination with USFWS or DFW, depending on agency jurisdiction.	DFW
WUS	**Waters of the United States**	
WUS-1. Identify and Quantify Wetlands and Other Waters of the United States	The distribution of wetlands (including vernal pools and other seasonal wetlands) in the Project area is described in Section 15.3.3 of the EIS/R. That section of the EIS/R also describes the acreage of effects on waters of the United States, based on the mapped distribution of these wetlands, hydraulic modeling and field observation. A delineation of waters of the United States has been submitted to the Corps for verification. The delineation was conducted according to methods established in the Corps *Wetlands Delineation Manual* and *Arid West Supplement* (Corps Environmental Laboratory 1987, 2008). Construction and modification of road crossings, control structures, fish barriers, fish passages, and other structures will be designed to minimize effects on waters of the United States, and will employ BMPs to avoid indirect effects on water quality.	Corps

Table 4.
Conservation Measures for Biological Resources That May Be Affected by Project Actions

Conservation Measure and Identifier	Applicable Habitat and/or Species, and Conservation Measure Description	Regulatory Agency
WUS-2. Obtain Permits and Compensate for Any Loss of Wetlands and Other Waters of the United States	The project proponent, in coordination with the Corps, will determine the acreage of effects on waters of the United States that will result from implementation of the SJRRP. The project proponent will adhere to a “no net loss” basis for the acreage of wetlands and other waters of the United States that will be removed and/or degraded. Wetland habitat will be restored, enhanced, and/or replaced at acreages and locations and by methods agreed on by the Corps and the Central Valley RWQCB, and DFW, as appropriate, depending on agency jurisdiction. The project proponent will obtain Section 404 and Section 401 permits and comply with all permit terms. The acreage, location, and methods for compensation will be determined during the Section 401 and Section 404 permitting processes. The compensation will be consistent with recommendations in the Fish and Wildlife Coordination Act Report (Appendix F of the PEIS/R).	Corps
CVS	**Central Valley Steelhead**	
CVS-1. Avoid Loss of Habitat and Risk of Take of Species	Impacts to habitat conditions (i.e., changes in flows potentially resulting in decreased flows in the tributaries, increases in temperature, increases in pollutant concentration, change in recirculation/recapture rates and methods, decrease in floodplain connectivity, removal of riparian vegetation, decreases in quality rearing habitat, etc.) are analyzed in consultation with NMFS. The Hills Ferry Barrier will be operated and maintained to exclude Central Valley steelhead from the Restoration Area during construction activities and until suitable habitat conditions are restored, and trapping and monitoring will occur to detect steelhead moving upstream and relocate them to the mouth of the Merced River. Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive. Before construction, Reclamation will conduct an education program for all agency and contracted employees relative to the Federally listed species that may be encountered within the Action Area, and required practices for their avoidance and protection. A NMFS-appointed representative will be identified to employees and contractors to ensure that questions regarding avoidance and protection measures are addressed in a timely manner. Disturbance of riparian vegetation will be avoided to the greatest extent practicable. A spill prevention plan will be prepared describing measures to be taken to minimize the risk of fluids or other materials used during construction (e.g., oils, transmission and hydraulic fluids, cement, fuel) from entering the San Joaquin River or contaminating riparian areas adjacent to the river itself. In addition to a spill prevention plan, a cleanup protocol will be developed before construction begins and will be implemented in case of a spill. Stockpiling of materials, including portable equipment, vehicles and supplies, such as chemicals, will be restricted to the designated construction staging areas, exclusive of any riparian and wetland areas. A qualified biological monitor will be present during all construction activities, including clearing, grubbing, pruning, and trimming of vegetation at each job site during construction initiation, midway through construction, and at the	NMFS

Table 4.
Conservation Measures for Biological Resources That May Be Affected by Project Actions

Conservation Measure and Identifier	Applicable Habitat and/or Species, and Conservation Measure Description	Regulatory Agency
	close of construction, to monitor implementation of conservation measures and water quality. The floodplain would be designed in accordance with the Rearing Habitat Design Objectives.	
CVS-2. Minimize Loss of Habitat and Risk of Take of Species	Construction BMPs for off-channel staging, and storage of equipment and vehicles, will be implemented to minimize the risk of contaminating the waters of the San Joaquin River by spilled materials. BMPs will also include minimization of erosion and stormwater runoff, as appropriate. Riparian vegetation removed or damaged will be replaced within the immediate area of the disturbance to maintain habitat quality. If individuals of listed species are observed present within the Project area, NMFS will be notified. NMFS personnel will have access to construction sites during construction, and following completion, to evaluate species presence and condition and/or habitat conditions. If bank stabilization activities should be necessary, then such stabilization will be constructed to minimize predator habitat, minimize erosion potential, and contain material suitable for supporting riparian vegetation.	NMFS
EFH	**Essential Fish Habitat (Pacific Salmonids)**	
EFH-1. Avoid Loss of Habitat and Risk of Take of Species	Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the Project are positive. A NMFS-appointed representative will be identified to employees and contractors to ensure that questions regarding avoidance and protection measures are addressed in a timely manner. Disturbance of riparian vegetation will be avoided to the greatest extent practicable. A spill prevention plan will be prepared describing measures to be taken to minimize the risk of fluids or other materials used during construction (e.g., oils, transmission and hydraulic fluids, cement, fuel) from entering the San Joaquin River or contaminating riparian areas adjacent to the river itself. In addition to a spill prevention plan, a cleanup protocol will be developed before construction begins and will be implemented in case of a spill. Stockpiling of materials, including portable equipment, vehicles and supplies, such as chemicals, will be restricted to the designated construction staging areas, exclusive of any riparian and wetland areas. A qualified biological monitor will be present during all construction activities, including clearing, grubbing, pruning, and trimming of vegetation at each job site during construction initiation, midway through construction, and at the close of construction to monitor implementation of conservation measures and water quality. The bottom topography of the San Joaquin River channel will be designed to decrease or eliminate predator holding habitat.	NMFS
EFH-2. Minimize Loss of Habitat and Risk of Take from Implementation of Construction Activities	Construction BMPs for off-channel staging and storage of equipment and vehicles will be implemented to minimize the risk of contaminating the waters of the San Joaquin River by spilled materials. BMPs will also include minimization of erosion and stormwater runoff, as appropriate. Riparian vegetation removed or damaged will be replaced, as applicable, in accordance with the Riparian Habitat Monitoring Management and Mitigation Plan, and will be coordinated with the USFWS and NMFS and/or other agencies as appropriate.	NMFS

**Table 4.
Conservation Measures for Biological Resources That May Be Affected by Project Actions**

Conservation Measure and Identifier	Applicable Habitat and/or Species, and Conservation Measure Description	Regulatory Agency
	If bank stabilization activities should be necessary, then such stabilization will be constructed to minimize predator habitat, minimize erosion potential, minimize sedimentation of the waterway, and contain material suitable for supporting riparian vegetation.	

Acronyms:

BMP = best management practice
CNDDB = California Natural Diversity Database
Corps = U.S. Army Corps of Engineers
DFW = California Department of Fish and Wildlife
NMFS = National Marine Fisheries Service
PEIS/R = Program Environmental Impacts Statement/Report
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
RWQCB = Regional Water Quality Control Board
SJRRP = San Joaquin River Restoration Program
USFWS = U.S. Fish and Wildlife Service

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3.0 Environmental Setting and Biotic Resources

The environmental setting focuses on Reach 2B, a section of the San Joaquin River which begins at the Chowchilla Bifurcation Structure and ends at Mendota Dam.[3] The Action Area also includes about 1,800 linear feet of river upstream of the Chowchilla Bifurcation Structure, about 1 mile of the river downstream of Mendota Dam, and a portion of Fresno Slough.

3.1 Habitat Description of Action Area

3.1.1 Climate

The region in which the Action Area occurs is semi-arid, with long, hot, dry summers and relatively mild winters. Winter temperatures are usually mild, but drop below freezing during occasional cold spells. The monthly average of the minimum daily temperature ranges from 36 to 66 degrees Fahrenheit (°F), and the monthly average of the maximum daily temperature ranges from 54 to 100°F (WRCC 2011). Based on long-term records of precipitation, the average annual precipitation in the Action Area is approximately 8.0 inches but increases moving easterly towards the mountains as the elevation increases (WRCC 2011). Approximately 90 percent of precipitation in the Action Area occurs from November through April (WRCC 2011).

3.1.2 Hydrology and Water Quality

The San Joaquin River flows generally northwest through the San Joaquin Valley before discharging into the Sacramento-San Joaquin Delta. Reach 2B is located between the Chowchilla Bifurcation Structure and Mendota Dam and is characterized by a single-thread, meandering, sand-bed channel that is bounded by local levees and a relatively flat overbank surface. The primary source of water to the upstream end of Reach 2B comes from releases from Friant Dam, which is generally considered very good in terms of water quality, having low temperature, low salinity, high dissolved oxygen (DO), low nutrient concentrations, and no known problems with trace elements or pesticides (McBain and Trush 2002). However, surface water quality in the Action Area can be degraded by low river flows, agricultural operations, and illegal dumping, resulting in increased concentrations of salts, pesticides, nutrients (from fertilizers), and trash and debris.

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[3] Existing conditions are defined as the conditions existing when the Notice of Intent and Notice of Preparation were filed, which was July 2009 for this Project and prior to Interim Flows. However, field data were collected at later dates, after the start of Interim Flows. Therefore, the best available information to describe existing conditions also includes periods after the start of Interim Flows.

Mendota Pool is primarily warm-water fish habitat. The pool is generally shallow, low velocity water that flows in various directions depending on delivery rate and the operation of diversions.

3.1.3 Aquatic Habitat

Mendota Pool is located at the confluence of Fresno Slough and the San Joaquin River. The San Joaquin River arm of Mendota Pool extends from Mendota Dam to San Mateo Avenue. San Mateo Avenue has a low-flow crossing consisting of a culvert and an earthen embankment supporting the roadbed which is overtopped during higher flows.

Water is typically delivered to Mendota Pool from the Delta-Mendota Canal and is withdrawn at several canal or pump locations in the Mendota Pool including Columbia Canal, Helm Ditch, Main Canal, Outside Canal, Fresno County Waterworks District Canal, Mowry pumps, and others. Water is also delivered to the Mendota Pool by the Mendota Pool Pumpers group as well as by river flows. Mendota Pool was dewatered biennially in mid-winter for maintenance of the Dam, but some locations held standing water during this several week period. Although recent repairs at Mendota Dam have reduced the need to dewater the Pool for dam inspections, Mendota Pool was most recently dewatered for maintenance in the winter of 2011 to 2012.

Prior to the start of Interim Flows in October 2009 and Restoration Flows in 2014, the section of Reach 2B between the Chowchilla Bifurcation Structure and San Mateo Avenue was mostly dry (SJRRP 2010a). Surface flows throughout Reach 2B occurred during very wet periods (about every 3 to 5 years). Water released from Mendota Dam was typically delivered to downstream water users. Downstream of the last diversion point, the river was typically dry.

Aquatic habitat in Reach 2B was either mostly absent within the dry section of the channel or was backwatered in the impounded water body. The river channel was composed of a sand bed with margins occupied by sparse riparian or ruderal vegetation (SJRRP 2010a). The portion of the Reach 2B channel upstream of San Mateo Avenue was composed of unconsolidated fine sand. Aquatic habitat was seasonal because flow was not sustained in the channel. The channel bed was generally devoid of a defined low-flow channel or aquatic habitat features such as pools and bars. Riparian vegetation was sparse and limited to the levees along the channel. Downstream of San Mateo Avenue, aquatic habitat was affected by the backwatering of Mendota Dam and sedimentation in Mendota Pool. The channel was defined by emergent, wetland, and riparian vegetation, including mature cottonwood trees, established along the backwatered portion of Mendota Pool. Most of the Mendota Pool was fairly shallow, and some areas also contained submerged aquatic vegetation. Mendota Pool contained mostly introduced fish and a few native fish.

Interim Flows transitioned to Restoration Flows on January 1, 2014. Since the start of Interim and Restoration Flows there have been some changes in Reach 2B, mostly between the Chowchilla Bifurcation Structure and San Mateo Avenue. The changes primarily consist of more regular inundation due to increased water releases from Friant Dam and the associated establishment of hydrophilic vegetation. Aquatic habitat includes a series of low gradient riffles, flatwater glides, and mid-channel pools (DFW 2010). However, in dry years, portions of the channel still experience extended periods of desiccation. The section of Reach 2B affected by backwater is visibly unchanged by Restoration Flows and generally persists as described above because it continues to have water year-round.

3.1.4 Aquatic Food Web

The aquatic food web in Reach 2B has been affected by modifications to habitat, introduction of nonnative species, water management activities, and alteration of water quality, which has substantially altered nutrient processing by the primary producers (diatoms and aquatic vegetation) and secondary producers (zooplankton and aquatic invertebrates), and has affected fish communities and other aquatic fauna (Brown and Moyle 1996).

Food web processes in Reach 2B are influenced by invertebrate production within the reach and by the drift of benthic invertebrates into and out of the reach. The quantity of insects that drift during times of flow into Reach 2B from upstream reaches is unknown. Reach 1 has gravel substrates and riffles which create productive habitat for benthic invertebrates, suggesting that many prey taxa are likely available for juvenile salmonids (Stillwater Sciences 2003). (Salmonids are those fishes from the *Salmonidae* family, such as salmon, trout, and char.) While many of these taxa have high propensity to drift and are likely important components of fish diets, how far they drift and whether they drift to locations downstream that do not retain gravel substrate (such as Reach 2B) is unknown. The amount of insect drift that enters Reach 2B would be affected by flows directed into Chowchilla Bypass at the Chowchilla Bifurcation Structure. The amount of insect drift from Reach 2B to downstream reaches would be affected by the proportion of inflow that is exported out of Mendota Pool. Mendota Pool habitat and food web processes would also be affected by water that is imported through the Delta-Mendota Canal and groundwater inputs from the Mendota Pool Pumpers.

Floodplains that support riparian vegetation or grasslands that are seasonally inundated can also provide a source of nutrients and primary and secondary producers that can propagate to downstream channels, if not exported at on-river diversions. Floodplain habitats typically produce small invertebrates with short life cycles, such as chironomids and cladocerans (McBain and Trush 2002). The timing, duration, and frequency of inundation influence the abundance and composition of invertebrate production and nutrient processing on floodplains (Ahearn et al. 2006, Grosholz and Gallo 2006). This resource availability, combined with warmer temperatures on the floodplains compared to main channel habitats, has been documented to accelerate juvenile salmonid growth in floodplain river systems (Jeffres et al. 2008). Under low flow conditions, main channel habitats such as the San Joaquin River mainstem support juvenile salmonid growth rates that are comparable to growth rates of fish in floodplain habitats (Blumenshine et al. 2015). This is likely due to the floodplain-like conditions (i.e., higher temperature, lower velocity, and low turbidity levels) that occur in main channels when flows are low. Habitat between the existing levees in Reach 2B currently consists of the main river channel with limited floodplain habitat areas that are not typically inundated due to low water discharge levels.

3.1.5 Fish Community

Native and nonnative fish species potentially found in the vicinity of Reach 2B are listed in Table 5~~Table 5~~. Nonnative fish species, which are continuously transported to Reach 2B via water imported from the Delta-Mendota Canal as well as from the Millerton Reservoir and Fresno Slough, may alter food webs and have adverse consequences to native fish species. These adverse effects include increased competition for resources, direct predation, and habitat or behavioral interference (Moyle 2002). Native fishes are particularly vulnerable to predation during early life stages due to their small size and weak swimming abilities.

Table 5.
Fish Species Potentially Present in the Vicinity of Reach 2B

Native Fishes	
Central Valley steelhead (*Oncorhynchus mykiss*)[+,1,2,3]	Threespine stickleback (*Gasterosteus aculeatus*)[5,6]
Tule perch (*Hysterocarpus traskii*)[6]	Pacific lamprey (*Lampetra tridentata*)[6]
Sacramento pikeminnow (*Ptychocheilus grandis*)[5,6]	Sacramento sucker (*Catostomus occidentalis*)[*,4,5, 6]
Sacramento blackfish (*Orthodon microlepidotus*)[6]	Sacramento splittail (*Pogonichthys macrolepidotus*)[*,5]
Hardhead (*Mylopharodon conocephalus*)[6]	Kern Brook lamprey (*Lampetra hubbsi*)[6]
Hitch (*Lavinia exilicauda*)[*,4,6]	Prickly sculpin (*Cottus asper*)[5,6]
River lamprey (*Lampetra ayresi*)[6]	Rainbow trout (*Oncorhynchus mykiss*)[5,6]
Chinook salmon (*Oncorhynchus tshawytscha*)[5]	Riffle sculpin (*Cottus gulosus*)[5]
Nonnative Fishes	
Threadfin shad (*Dorosoma petenense*)[*,4,5,6]	Largemouth bass (*Micropterus salmoides*)[*,4,5,6]
Black crappie (*Pomoxis nigromaculatus*)[*,4,5,6]	Golden shiner (*Notemigonus crysoleucas*)[*,4,5,6]
Inland silverside (*Menidia beryllina*)[*,4,5,6]	White catfish (*Ameiurus catus*)[*,4,5,6]
Striped bass (*Morone saxatilis*)[*,4]	Pumpkinseed (*Lepomis gibbosus*)[*,4,5,6]
Channel catfish (*Ictalurus punctatus*)[*,4,5,6]	Western mosquitofish (*Gambusia affinis*)[*,4,5,6]
Bluegill (*Lepomis macrochirus*)[*,4,5,6]	Warmouth (*Lepomis gulosus*)[*,4,5,6]
White crappie (*Pomoxis annularis*)[*,4,5,6]	American shad (*Alosa sapidissima*)[*,4]
Goldfish (*Carassius auratus*)[*,4,5,6]	Brown bullhead (*Ameiurus nebulosus*)[*,4,5,6]
Common carp (*Cyprinus carpio*)[*,4,5,6]	Striped bass (*Morone saxatilis*)[*,5,6]
Green sunfish (*Lepomis cyanellus*)[*,4,5,6]	Yellow bullhead (*Ameiurus natalis*)[*,5]
Redear sunfish (*Lepomis microlophus*)[*,5,6]	Spotted bass (*Micropterus punctulatus*)[*,5,6]
Black bass spp. (*Micropterus spp.*)[*,5]	Red shiner (*Cyprinella letrensis*)[*,5,6]
Black bullhead (*Ameiurus melas*)[*,4,5,6]	Fathead minnow (*Pimephales promelas*)[*,5,6]
Shimofuri goby (*Tridentiger bifasciatus*)[*,5,6]	Bigscale logperch (*Percina macrolepida*)[*,4,5,6]
Redeye bass (*Micropterus coosae*)[6]	Weather loach (*Misgurnus anquillicaudatus*)[*]

Notes:
[+] Fish species that are ESA Threatened or Endangered and will be further discussed in Section 3.3
* Fish species that are also found in Reaches 2A and/or 3
[1] USFWS Species List – Fresno and Madera County Search
[2] USFWS Species List - Bonita Ranch, Coit Ranch, Firebaugh, Firebaugh NE, Gravelly Ford, Jamesan, Mendota Dam, Poso Farm, and Tranquility Quad Search
[3] CNDDB - Bonita Ranch, Coit Ranch, Firebaugh, Firebaugh NE, Gravelly Ford, Jamesan, Mendota Dam, Poso Farm, and Tranquillity Quad Search
[4] Jones and Stokes 1986, Scientific and common names have been updated from Jones and Stokes (1986) to be consistent with current nomenclature (Nelson et al. 2004).
[5] Hutcherson 2013, unpublished data.
[6] Workman and Portz 2013

3.1.6 Terrestrial Habitat

The habitat surrounding the Action Area consists of a narrow and fragmented corridor of woody and scrub vegetation along Reach 2B upstream of Mendota Pool with a somewhat healthier stand, supported by the presence of water, along the San Joaquin River arm of the Mendota Pool. The backwater area of the San Joaquin River arm of the Mendota Pool supports riparian vegetation that is primarily composed of Fremont cottonwood (*Populus fremontii*), willow (*Salix spp*.), box elder (*Acer negundo*), and ash (*Fraxinus latifolia*). Emergent wetland communities are also present in the San Joaquin River arm of the Mendota Pool backwater area. Starting a few miles upstream from Mendota Dam and especially upstream of San Mateo Avenue, the channel banks contain riparian scrub and willow scrub communities.

Land use within and surrounding the Action Area is primarily agriculture and is interspersed with native scrub and grassland habitat, public parks, and other areas kept free of vegetation by regular disturbance. Disturbed areas include dirt roads, canals, levees, structures, and landscaping.

3.2 Study Methods

Database searches were conducted to identify special-status fish that could potentially occur in the Action Area. Two primary databases were reviewed:

- California Natural Diversity Database (CNDDB; DFW 2015): All records from the Bonita Ranch, Coit Ranch, Firebaugh, Firebaugh NE, Gravelly Ford, Jamesan, Mendota Dam, Poso Farm, and Tranquility U. S. Geological Survey 7.5-minute quadrangles in this database were reviewed.
- USFWS Sacramento Field Office Species List (USFWS 2015): All species on this list were generated at the Sacramento USFWS website for Fresno and Madera counties. The list was originally generated April 24, 2015 and was updated December 10, 2015.

3.3 Federally-Listed Species and Designated Critical Habitat

The CNDDB and USFWS Sacramento Field Office database searches returned five special-status fish species (Table 6) potentially occurring in the region. Special-status fish species include those species that are federally listed, proposed for Federal listing, Federal candidate species, State listed, State fully protected species, or species of special concern. Two of these species, Central Valley steelhead and Central Valley spring-run Chinook salmon, have low potential to occur in the Action Area and are addressed in this BA; the others are not anticipated to occur in the project vicinity or be affected by the proposed action, and therefore are not further discussed in this BA.

Table 6.
Anadromous Fish Species Potentially Occurring in the Project Vicinity

Species	Status	Source	Potential to Occur (PTO)
Central Valley steelhead, *Oncorhynchus mykiss*	FT	USFWS County, CNDDB	Low PTO: Currently, there is a very low potential for steelhead to arrive naturally in Reach 2B as they would need to successfully bypass the Sack Dam and Mendota Dam. As the Project is constructed, passage into Reach 2B would become easier as fish passage structures are constructed at Sack Dam and the Mendota Pool Bypass is built. There have been no steelhead captured in two years of monitoring efforts in Reaches 4B and 5, the most downstream reaches in the SJRRP, and it is now thought that steelhead are extirpated from all reaches of the SJRRP Restoration Area (SJRRP 2012b, SJRRP 2013).
Central Valley spring-run Chinook salmon, *Oncorhynchus tshawytscha,* Nonessential Experimental Population	-	N/A	Moderate PTO: Although Central Valley spring-run Chinook salmon were extirpated from the San Joaquin River in the 1950's, juvenile fish reared at the Feather River Fish Hatchery were released in the San Joaquin River just above the confluence with the Merced River in 2014 and 2015 and additional releases are planned for 2016. Currently, there is a very low potential for Chinook salmon to arrive naturally in Reach 2B as they would need to successfully bypass the Sack Dam and Mendota Dam. As the Project is constructed, passage into Reach 2B would become easier as fish passage structures are constructed at Sack Dam and the Compact Bypass is built.
*Little Kern golden trout (*Oncorhynchus aguabonita whitei*)	FT	USFWS County	No PTO: Occurs only in the main stem and tributaries of the Little Kern River (Tulare County).
*Owens Tui chub, *Gila bicolor snyderi*	FE	USFWS County	No PTO: Occurs at only six locations on the east side of the Sierra Nevada.
*Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*	FT	USFWS County	No PTO: Occurs on the east side of the Sierra Nevada.
*Paiute cutthroat trout, *Oncorhynchus clarki seleniris*	FT	USFWS County	No PTO: Occurs in streams in the Sierra Nevada.

Key:
CNDDB = California Natural Diversity Database
PTO = potential to occur
USFWS = U.S. Fish and Wildlife Service
FT = Federally Threatened
FE = Federally Endangered
*Because these species are not covered under the jurisdiction of NMFS, they will not be further discussed in this BA. A separate BA will be submitted to USFWS.

3.3.1 Central Valley Steelhead

Central Valley steelhead DPS is listed as threatened under the ESA, as amended (63 FR 13347). Section 9 of ESA and its implementing regulations prohibit take of Central Valley steelhead. Take is defined by ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal. Take may include significant habitat modification or degradation that results in killing or injuring steelhead by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter.

Life History

The Central Valley steelhead (*Oncorhynchus mykiss*) DPS consists of naturally spawned anadromous populations of *O. mykiss* downstream of natural and man-made impassable barriers in the Sacramento and San Joaquin rivers and their tributaries. Steelhead can be divided into two life history types, winter (ocean-maturing) and summer (river-maturing), based on their sexual maturity at river entry and the duration of their spawning migration. Only winter run types are presently found within the Central Valley. Two artificial propagation programs are considered part of the DPS: the Coleman National Fish Hatchery and the Feather River Fish Hatchery steelhead hatchery programs. Central Valley steelhead generally leave the ocean from August through April and move upstream into Central Valley rivers. Spawning takes place from December through April with a peak between January and March. Steelhead are iteroparous (i.e., capable of spawning more than once over several years) and 17 to 23 percent of post-spawn adults (i.e., kelts during this life stage) can return to the ocean where they will mature and possibly migrate inland to spawn again (Boggs et al. 2008).

Juvenile steelhead rear in cold water streams in riffles, runs, and pools. Most steelhead will rear for at least a full year before they begin emigrating downstream to the ocean. Emigration occurs when fish reach 6 to 8 inches in size and begin to transform from a resident juvenile form to a smolt. Emigration can occur from fall through spring with a peak from February through April.

NMFS has defined six primary constituent elements of Central Valley steelhead habitat, including: (1) freshwater spawning sites; (2) freshwater rearing sites with sufficient shade, foraging areas, and space for growth and movement; (3) freshwater migration corridors with sufficient areas of cover; (4) estuarine areas that provide areas for foraging and cover; (5) near shore marine areas that allow for juvenile transition from natal streams to offshore environments; and (6) off-shore marine areas with sufficient forage (NMFS 2005).

Presence in the Action Area

O. mykiss have been captured in the three main tributaries of the San Joaquin River including the Stanislaus, Tuolumne, and Merced rivers. They likely do not currently occur in Reach 5 or upstream within the San Joaquin River, including Reach 2B (Eilers et al. 2010). Two successive years of monitoring in 2012 and 2013 failed to capture steelhead in Reaches 4B and 5, leading to the belief that steelhead have been extirpated from all reaches of the SJRRP Restoration Area (SJRRP 2012b, SJRRP 2013).

Monitoring will continue in the downstream reaches of the SJRRP Restoration Area as part of the Central Valley Steelhead Monitoring Plan (SJRRP 2015b).

There is currently a very low potential for steelhead to pass downstream barriers and arrive naturally in Reach 2B. Central Valley steelhead cannot access the Project Area during most flows because there is no fish passage over Sack Dam, although passage is possible during very high flow events. Should Central Valley steelhead swim over Sack Dam during higher flow events, they may not be able to ascend Mendota Dam. Central Valley steelhead could potentially access the San Joaquin River upstream of Mendota Dam when the flash boards are removed during very high flow events. If adult steelhead were to successfully migrate and spawn in Reach 1, then juveniles could access Reach 2B under current conditions by swimming downstream. Kelts could also emigrate through Reach 2B from Reach 1 after spawning. If steelhead were present in the Action Area, the likelihood of survival would be low as current conditions do not reliably provide suitable rearing or migratory habitat.

Presence of anadromous fish would initially be controlled by the Program. Over the course of Project construction, the likelihood of salmonid presence in the area would increase due to the construction of fish passage in the Restoration Area. During the early stages of Project construction (approximately 2016 through 2019), a temporary trap and haul program is expected to be necessary to provide fish passage in portions of the Restoration Area. No passage would be provided at Mendota Dam and it would continue to be passable under only very high flows. The likelihood of steelhead presence in the Action Area would continue to be low. Steelhead monitoring in Reach 5 would occur when the Hills Ferry Barrier is not in place (mid-December through mid-September) and when Restoration Flows meet with the Merced River by March 15th. When monitoring is taking place, fyke traps would be installed and the majority of migrating steelhead would be trapped and released at the mouth of the Merced River. Some steelhead would bypass the fyke traps and continue migrating upstream, potentially entering the Action Area. However, due to the monitoring efforts, there would be some warning that steelhead could be present in the San Joaquin River during construction so that an increased effort can be made to avoid impacts to steelhead during these times. If steelhead successfully migrate and spawn in Reach 1, juveniles and kelts could emigrate through the Action Area during construction. Steelhead present in the Action Area during the early stages of Project construction would likely experience low survival rates as the conditions would not yet reliably provide suitable rearing or migratory habitat.

As Project construction progresses (approximately 2020 to 2021), a permanent fish passage structure would become operational at Sack Dam, increasing the possibility that steelhead could enter the Action Area. Mendota Dam would continue to be passable during only high flows and the Compact Bypass may not yet be open. Trapping and monitoring of migrating steelhead would continue to help inform Reclamation of the possible migration of steelhead through the Action Area during construction. There would likely be poor survival of steelhead present in the Action Area during this period as suitable rearing and migratory habitat would not be reliably present.

Beginning in 2021, the Compact Bypass channel would open, allowing for unimpeded migration through the Action Area. Once the Compact Bypass channel is opened, the likelihood of steelhead migrating through the Action Area to spawn in Reach 1 would increase. Similarly, the likelihood of emigrating juveniles and kelts would increase after the Compact Bypass is opened. In-water construction of the Mendota Pool Control Structure and the Chowchilla Fish Passage Structure would continue to occur until 2024. Once the floodplain is restored and the Project is complete in 2027, the likelihood of survival of steelhead in Reach 2B would increase due to the presence of high quality rearing and migratory habitat. If and when steelhead recolonize the upper San Joaquin River, they would most likely spawn in Reach 1 and utilize Reach 2B as a migration corridor and as rearing habitat.

Estimation of Abundance in Reach 2B

Because no spawning population of Central Valley steelhead currently exists in the upper reaches of the San Joaquin River, an estimate of the number of Central Valley steelhead potentially occurring in the Action Area in the future, sometime during or after construction of the Project, was calculated using data of non-hatchery origin adult and juvenile Central Valley steelhead from the Mokelumne River system.

Spawning Adults. The number of non-hatchery origin adult steelhead (i.e., steelhead with intact adipose fins) was divided by the estimated length of available habitat from the Mokelumne River system to obtain the density of fish spawning per mile of habitat. Between 2002 and 2010, an average of 22 adult steelhead (wild fish greater than 16 inches) per year returned to the river (MRHS 2012). The length of available habitat on the Mokelumne River was estimated to be 33.5 river miles, which is the distance between the confluence with the Sacramento-San Joaquin Delta and the Camanche Dam, the upstream limit of anadromous salmonid migration on the Mokelumne River (Merz and Setka 2004). This area contains suitable temperatures and flows to support the migration of spawning adults, but not all available habitat is necessarily spawning habitat. Based on this calculation, each river mile of the Mokelumne River supports 0.7 spawning adults annually.

Similarly to the available habitat estimate for Mokelumne River, available habitat for the San Joaquin River was defined as habitat containing suitable temperatures and flows to support spawning adult migration, but not necessarily containing suitable spawning habitat. Currently such habitat is limited to Reach 1A, where available salmonid habitat has been identified using temperature and flow models (Reclamation 2014). These models predict that a total of 24 river miles of available habitat exists from below Friant Dam (Mile Post [MP] 267) to State Route 99 Bridge (MP 243; Reclamation 2014).

In order to calculate the number of adult steelhead that could potentially spawn in Reach 1A, the estimated number of spawning adults per river mile in the Mokelumne River was multiplied by the number of river miles containing suitable habitat in Reach 1A. This calculation assumes that Reach 1A will support a density of spawning adults similar to the Mokelumne River, and that the density of spawning habitat in Reach 1A is similar to the Mokelumne River. Based on this calculation, Reach 1A would support 17 spawning adult Central Valley steelhead annually (rounded up to the nearest whole fish). The rate of steelhead iteroparity is estimated to be between 17 and 23 percent in California (Boggs et al. 2008). Therefore, of the total number of estimated spawning adults, 4 kelts could survive spawning and emigrate through Reach 2B annually.

Emigrating Juveniles. The number of non-hatchery origin juveniles (i.e., juveniles with intact adipose fins) was taken from rotary screw trap data (Bilski et al., 2011, 2013, and 2014) with an average annual total of 294 emigrating juveniles (rounded up to the nearest whole fish) from February to June of 2011, 2013, and 2014 (Table 7).

Table 7.
Monthly Totals of Juvenile Emigrating Steelhead (No Adipose Clip) in the Lower Mokelumne River in 2011, 2013, and 2014.

Year	Month					Total
	Feb	Mar	Apr	May	June	
2010-2011	2	4	38	172	121	337
2012-2013	22	82	114	129	7	354
2013-2014	10	43	76	41	19	189
Average/sampling year	11.33	43	76	114	49	293.33

Additionally, an estimated number of emigrating juveniles was calculated using the assumption of 17 spawning adult Central Valley steelhead in the San Joaquin River (See Spawning Adults calculation above). Assuming the male to female ratio is 1:1, there would be approximately 9 spawning females. A female steelhead can carry approximately 2,000 eggs per kilogram (kg) of body weight (Moyle 2002). Spawning female steelhead weigh an average of 0.68 kg; therefore, a typical spawning female can carry approximately 1,360 eggs. The survival of steelhead from egg to smolt is 0.014(Williams 2010), so each spawning female can potentially produce 19 smolt annually. If each of the estimated 9 spawning females in the San Joaquin River produced 19 smolt annually, there would be a total of 171 juveniles (rounded up to the nearest whole fish) that could potentially survive, rear in, and emigrate through Reach 2B from February to June.

The number of emigrating juveniles from the Mokelumne River rotary screw trap (294 emigrating juveniles) and the number calculated using the adult fecundity and survival assumptions (171 juveniles) were averaged to obtain a population estimate of 233 emigrating juvenile Central Valley Steelhead in the San Joaquin River.

Critical Habitat

Critical habitat has been designated for Central Valley steelhead, but it does not occur within the Action Area.

3.3.2 Central Valley Spring-Run Chinook

The USFWS official species list does not include Central Valley spring-run Chinook salmon, but an experimental population of Central Valley spring-run Chinook salmon is included in this BA. The 2012 NMFS Programmatic BO for the SJRRP establishes guidelines for the reintroduction, monitoring, and management of Chinook salmon in all reaches of the San Joaquin River including Reach 2B (NMFS 2012). As an element of the SJRRP, an experimental population of Central Valley spring-run Chinook salmon is being reintroduced to the San Joaquin River. NMFS promulgated an ESA Section 10(j) rule designating this population as a NEP, which provides take exceptions under the Section 4(d) rule. Because Central Valley spring-run Chinook salmon in the SJRRP Restoration Area have been designated by NMFS as part of a NEP in accordance with Section 10(j) of the ESA, the population is treated as a candidate species.

Life History

The historical range of Central Valley spring-run Chinook salmon ESU included the Sacramento and San Joaquin River basins and stretched from Siskiyou and Modoc counties in the north to Fresno County in the south. The ESU's range has been dramatically reduced by the construction of dams and due to its extirpation from the San Joaquin River basin. Currently, the Central Valley spring-run Chinook salmon ESU consists primarily of three populations in three tributary systems (Mill, Deer, and Butte creeks), as well as Feather River and Clear Creek, which are all located within the Sacramento River basin. Recent reintroductions have also established a run in Battle Creek. The population uses rearing and migration habitats in the Sacramento River basin and Delta, San Francisco Bay, and offshore ocean waters.

Prior to their extirpation from the San Joaquin River, Central Valley spring-run Chinook salmon migrated upstream between April and early July, with most adults migrating upstream in May and June. Spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months (stream-type life history) (WCCSBRT 1997). Spawning occurs in Sacramento River tributaries from late September through mid-November. Fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean. Spring-run Chinook salmon generally mature between 2 and 4 years of age.

In addition to rearing in natal streams, spring-run Chinook salmon juveniles rear in the lower part of nonnatal tributaries and intermittent streams during the winter months (Maslin et al. 1997). Emigration can be highly variable; some juveniles may begin outmigrating soon after emergence, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (DFW 1998). The emigration period for spring-run Chinook salmon extends from November to early May. Emigration appears to coincide with high precipitation and high river flows.

Presence in the Action Area

Historically, Central Valley spring-run Chinook salmon spawned in the San Joaquin River from about the present day location of Friant Dam to as far upstream as Mammoth Pool (RM 322) (McBain and Trush 2002). During the late 1930s and early 1940s, as Friant Dam was being constructed, large runs continued to return to the river. After the dam was completed and the reservoir was filling, runs of 30,000 to 50,000 fish continued to return and spawn in the river downstream of Friant Dam. These runs were completely gone by 1950, as diversions from Friant Dam resulted in the river being dry at Gravelly

Ford (McBain and Trush 2002). The occurrence data and available information suggest that Central Valley spring-run Chinook salmon were not recently present within the Project area prior to SJRRP restoration activities.

Beginning in 2014, the Program released Central Valley spring-run Chinook salmon into the San Joaquin River. These hatchery-reared fish are designated a NEP under the ESA 10(j) and 4(d) rule and are treated as a candidate species (SJRRP 2014). The NEP designation applies to the San Joaquin River area from Friant Dam to Mossdale, and associated waterways accessible to anadromous fish. On April 17th and 18th, 2014, 60,114 Feather River Fish Hatchery Central Valley spring-run Chinook salmon juveniles were released just above the confluence with the Merced River (NMFS 2015). The Program released an additional 54,000 juvenile Central Valley spring-run Chinook salmon from the Feather River Fish Hatchery into the San Joaquin River just upstream of the confluence with the Merced River in February 2015 (SJRRP 2015c). A third release of juvenile spring-run Chinook salmon is planned for 2016.

Some of the hatchery-reared juvenile Central Valley spring-run Chinook salmon may return to the San Joaquin River as early as spring 2016, although their abundance would likely be limited by the 2014 and 2015 dry year conditions. Adult spring-run Chinook salmon migrating through the San Joaquin River would be trapped at the Hills Ferry Barrier and hauled to Reach 1 until there is unimpeded passage in the Restoration Area, which is anticipated to occur in 2021. Some migrating adult spring-run Chinook salmon may bypass the traps at the Hills Ferry Barrier location and continue migrating upstream. In order for these individuals to enter the Action Area, they would need to ascend both Sack Dam and Mendota Dam, which would likely be possible only during high flow events when the flash boards are removed at Mendota Dam. If adult spring-run Chinook successfully spawn in Reach 1, either after migrating naturally through the Restoration Area or being transported from the Hills Ferry Barrier, juveniles could emigrate through the Action Area during the early stages of construction (approximately 2017 to 2019). If spring-run Chinook salmon were present in the Action Area during the early stages of construction, the likelihood of survival would be low as current conditions do not reliably provide suitable spawning, rearing, or migratory habitat

As Project construction progresses (approximately 2020 to 2021), a permanent fish passage structure would become operational at Sack Dam, increasing the possibility that adult spring-run Chinook could naturally enter the Action Area. However, Mendota Dam would continue to be passable during only high flows and the Compact Bypass would not yet be open. Trapping of migrating adults would continue at the Hills Ferry Barrier location and individuals would continue to be released in Reach 1. Juveniles may be present in the Action Area if spawning is successful in Reach 1. There would likely be poor survival of spring-run Chinook in the Action Area during this period as suitable spawning, rearing, and migratory habitat would not be reliably present.

Beginning in 2021, the Compact Bypass channel would open, allowing spring-run Chinook salmon to migrate through the Action Area unimpeded. At this point, trap and haul from the Hills Ferry Barrier to Reach 1 would be unnecessary and would cease. Once the Compact Bypass channel is opened, the likelihood of spring-run Chinook salmon migrating through the Action Area to spawn in Reach 1 would significantly increase. Similarly, the likelihood of emigrating juveniles would significantly increase after the Compact Bypass is opened. In-water construction of the Mendota Pool Control Structure and the Chowchilla Fish Passage Structure would continue to occur until 2024. Once the floodplain is restored and the Project is complete in 2027, survival of spring-run Chinook salmon in Reach 2B would increase due to the presence of high quality rearing and migratory habitat. Spring-run Chinook salmon would most likely spawn in Reach 1 and utilize Reach 2B as a migration corridor and as rearing habitat.

Critical Habitat

Critical habitat has been designated for Central Valley spring-run Chinook salmon, but it does not occur within the Action Area.

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4.0 Potential Effects and Avoidance and Minimization Measures

4.1 Effects to Central Valley Steelhead and Central Valley Spring-run Chinook Salmon

The overall effect of the Project, combined with other SJRRP actions, would improve habitat in the Project area for salmonids; however, some impacts to Central Valley steelhead or Central Valley spring-run Chinook salmon could potentially occur during Project activities. For the purposes of this BA, effects of the Project are separated into two types: effects that would occur during Project construction (approximately 2016 to 2027) and those that would occur during long-term operation.

4.1.1 Potential Effects During Construction

Construction activities with potential to impact Central Valley steelhead and Central Valley spring-run Chinook salmon include removal of the San Mateo Avenue crossing, installation of the Columbia Canal intake siphon in Mendota Pool, construction of the Mendota Pool Control Structure, installation of sheet piles along the north levee prior to the construction of the Compact Bypass Control Structure and excavation of the Compact Bypass immediately upstream of the control structure, and construction of the Chowchilla Fish Passage Structure.

Construction of the Compact Bypass downstream of the control structure would occur in what is currently upland habitat with soil plugs in place for the duration of construction. Therefore, there would be no potential effects to Central Valley steelhead and Central Valley spring-run Chinook salmon as a result of construction of the Compact Bypass.

Potential for Injury or Mortality

In general, the Action Area currently contains poor quality habitat for salmonids. The Action Area does not presently contain salmonid spawning habitat or support salmonid spawning. While juvenile salmonids could potentially utilize the Action Area for rearing, the quality of rearing habitat is also poor.

Presently, there is a very low potential for Central Valley steelhead or Central Valley spring-run Chinook salmon to enter Reach 2B by swimming up the main San Joaquin River channel during high flows when the considerable downstream barriers are temporarily passible. During the early stages of Project construction it would be possible, but unlikely, for Central Valley steelhead or Central Valley spring-run Chinook salmon to migrate through or occur in the Action Area. Migrating adult spring-run Chinook salmon in Reach 5 would be transported to Reach 1, so there is a possibility that juveniles could emigrate through the Action Area if spawning is successful. As Project construction progresses, the Sack Dam Fish Passage facility would become fully operational, allowing Central Valley steelhead and Central Valley spring-run Chinook salmon to more easily enter Reach 2B by migrating up the main San Joaquin River channel. Once the Compact Bypass is open, there would be unimpeded passage to the Action Area. Although there is currently a low potential for Central Valley steelhead or Central Valley spring-run Chinook salmon to enter Reach 2B, the likelihood of presence in the Action Area would increase as the Project is constructed due to both Project activities and Program actions. In the event that Central Valley steelhead or Central Valley spring-run Chinook salmon are present in the Action Area during construction, the proposed Project construction activities may result in adverse effects due to injuring or killing individuals.

Cofferdam Construction. Many of the Project's construction activities would occur in what is currently upland habitat, in which case there would be no potential to injure or kill Central Valley steelhead or Central Valley spring-run Chinook salmon. Construction activities that must occur in the San Joaquin River channel would be isolated from the river through the use of cofferdams. Cofferdams would be installed to allow construction to occur in isolation from the river channel or Mendota Pool, in the dry (to the extent that dewatering achieves a dry condition), to minimize river turbidity, and to limit contact between Project activities and the channel segments potentially supporting Central Valley steelhead or Central Valley spring-run Chinook salmon. Activities requiring the use of cofferdams include the removal of the San Mateo Avenue crossing, installation of the Columbia Canal intake siphon in Mendota Pool, construction of the Mendota Pool Control Structure, and construction of the Chowchilla Fish Passage Structure. Construction of the Mendota Pool Control Structure across the existing river channel would require cofferdams in two phases to allow construction without blocking flow: one phase would include construction of the control structure itself and the other phase would include construction of a wing dam on the south side of the channel.

Installation of cofferdams would require enclosing and dewatering the area contained by the cofferdam, which may cause entrainment of salmonids. Fish entrained behind the cofferdam would be exposed to increased water temperatures and decreased DO concentrations, and would be vulnerable to predation by other entrained fish and potential stranding (Cushman 1985). The low frequency of salmonid occurrence in Reach 2B makes it unlikely that these species would be encountered during Project construction. However, because downstream fish passage projects are scheduled to be operational prior to Project construction completion, the potential for salmonids to be present in the Action Area would increase over the duration of Project construction.

Adverse effects to Central Valley steelhead and Central Valley spring-run Chinook salmon resulting from cofferdam installation would be minimized by implementing the Conservation Measures described in Section 2.2.28, Table 4 and listed in Section 2.2.3, Fish Passage Criteria. In addition, a Fish Rescue and Relocation Plan would be developed by Reclamation or contractors and provided to NMFS for approval 90 days prior to cofferdam construction. The plan will include methods of flow bypass, diversion, dewatering, salmonid collection, transport and release, water quality data, and formation of a team of qualified biologists with expertise in handling, collecting, and relocating salmonids. NMFS would have 45 days to review the Fish Rescue and Relocation Plan so contractors can be given time to make necessary changes, if any, to follow NMFS guidance or criteria while staying on construction schedule.

Effects on Habitat

The Project would restore floodplain habitat and provide upstream and downstream fish passage around Mendota Dam for adult salmonids and other native fishes and provide downstream passage for juvenile salmonids. However, there may be effects to salmonid habitat from construction activities. Most potential adverse effects would be temporary in nature resulting from construction activities during implementation of the Project.

Loss of Habitat. The proposed Project construction activities may result in the temporary loss of habitat that may be occupied by Central Valley steelhead or Central Valley spring-run Chinook salmon. Loss of habitat could occur due to construction of cofferdams, which would dewater portions of the channel. Removal of riparian vegetation could cause a temporary reduction in cover for salmonids. Reach 2B is currently unavailable and unsuitable for salmonid spawning, rearing, or migration and would likely remain unsuitable in the absence of the Project. During construction the Project would cause temporary loss of salmonid habitat due to dewatering or removal of riparian vegetation; however after Project completion and in the long term, the Project would result in a net increase in rearing and migration habitat for salmonids.

Erosion and Sedimentation. The proposed Project activities, including construction of the cofferdams, may cause erosion, which could result in sediment entering the existing San Joaquin River channel. Activities requiring the use of cofferdams include the removal of the San Mateo Avenue crossing, installation of the Columbia Canal intake siphon in Mendota Pool, construction of the Mendota Pool Control Structure, and construction of the Chowchilla Fish Passage Structure. Adverse effects of increased sedimentation in the river channel could lead to a reduction in prey abundance for salmonids, but would be minimized by implementing the Conservation Measures described in Section 2.2.28, Table 4 and listed in Section 2.2.3, Fish Passage Criteria.

Turbidity. Construction of Project components that occur in the San Joaquin River channel may cause temporary increases in turbidity in the Action Area. Installation of cofferdams, which would occur in association with the removal of the San Mateo Avenue crossing, construction of the Columbia Canal intake siphon in Mendota Pool, construction of the Mendota Pool Control Structure, and construction of the Chowchilla Fish Passage Structure, may cause temporarily elevated turbidity levels as sheet piles are driven. Prior to construction of the Compact Bypass Control Structure and excavation of the area immediately upstream of the control structure, a row of sheet piles may be driven along the existing levee north of the San Joaquin River between the levee and the river. Driving of these sheet piles may also temporarily increase turbidity levels in the San Joaquin River. Finally, creation of the Pilot Channel, which would create a smoother transition between Reach 2B and the Bypass channel and reduce sedimentation downstream into Reach 3, would require dredging of the San Joaquin River for approximately 1 mile beginning at the Compact Bypass Control Structure and moving upstream.

If salmonids are present in the Action Area during construction, elevated turbidity levels may negatively impact foraging ability, which could in turn lead to reductions in growth. Moderate increases in turbidity could impair movement and navigation, while extreme increases in turbidity could cause injury or mortality. Turbidity would occur only during construction activities and would therefore be localized and short-term. Adverse effects to Central Valley steelhead and Central Valley spring-run Chinook salmon resulting from turbidity would be minimized by implementing the Conservation Measures described in Section 2.2.28, Table 4 and listed in Section 2.2.3, Fish Passage Criteria. In addition, excavation of the Pilot Channel, which would likely create the largest increase in turbidity, would occur during summer months when high temperatures in Mendota Pool would discourage salmonid presence.

Temperature. The Project may cause temporary changes in water temperature in the existing channel. Water temperatures may increase if Project activities alter flows or channel morphology during construction. In addition, removal of riparian vegetation associated with Project activities could cause a temporary reduction in shading of the existing channel and thus lead to increases in water temperature.

Steelhead reach optimal growth rates when water temperatures are between 15 and 18 degrees Celsius (°C; Moyle 2002). Moderate increases in water temperature (to 22°C) cause behavioral changes associated with thermal stress including decreased rates of foraging and increased intraspecific aggression in steelhead (Nielsen et al. 1994). Water temperatures above 25°C cause significant steelhead mortality (Myrick and Cech 2001). Adult Chinook salmon prefer to migrate upstream from the Delta to the San Joaquin River when water temperatures are 18.3°C, however they would continue to migrate until water temperatures reach 21.1°C (Boles et al. 1988). Adult Central Valley spring-run Chinook salmon in the Sacramento-San Joaquin River system spend the summer in pools below 21 to 25 °C (Moyle et al. 1995). Spawning occurs between 4.5 and 12.8°C and rearing juveniles can survive temperatures ranging from 0 to 24°C (Raleigh et al. 1986). Sustained water temperatures above 27°C cause mortality in adult Central Valley spring-run Chinook salmon (Moyle et al. 1995).

Pollutants. Accidental spills of hazardous material used during construction (e.g., oils, transmission and hydraulic fluids, cement, fuel) could occur during construction. These materials could enter the San Joaquin River or contaminate riparian areas adjacent to the river. Adverse effects of pollutants in the river channel could include injury or mortality of Central Valley steelhead or Central Valley spring-run Chinook salmon. The introduction of pollutants may also harm salmonids if the pollutants cause a reduction in available prey abundance or if contaminated prey are consumed by salmonids. However, adverse effects would be avoided through implementation of Conservation Measures described in Section 2.2.28, Table 4 and listed in Section 2.2.3, Fish Passage Criteria .

Noise

The proposed Project construction activities may produce noise that has the potential to harm Central Valley steelhead or Central Valley spring-run Chinook salmon if they are present near Project activities during construction. Sheet pile installation would occur during construction of cofferdams for the removal of the San Mateo Avenue crossing, installation of the Columbia Canal intake siphon in Mendota Pool, construction of the Mendota Pool Control Structure, and construction of the Chowchilla Fish Passage Structure. Sheet piles may also be installed along the existing north levee adjacent to the future entrance of the Compact Bypass prior to the construction of the Compact Bypass Control Structure and excavation of the area immediately upstream of the control structure.

Sheet pile installation would create noise and vibrations within the water column that could impact fish that are present near the work area. Underwater noise generated during sheet pile installation would most likely cause behavioral changes in salmonids, if present. Fish may display dispersal or avoidance behavior in response to underwater noise. Individuals may be injured or killed if they occur directly adjacent to Project activities that produce extremely loud underwater noise.

Fundamentals of Underwater Sound. Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water. Sound is generally characterized by several variables, including frequency and intensity. Frequency describes the pitch of a sound and is measured in Hertz; intensity describes the loudness of a sound and is measured in decibels (dB). Decibels are measured using a logarithmic scale.

When a pile driving hammer strikes a pile, a pulse is created that propagates through the pile and radiates sound into the water and the ground substrate, as well as the air. The sound pressure pulse, as a function of time, is referred to as the waveform. The peak pressure is the highest absolute value of pressure over measured waveform and can be a negative or positive pressure peak. Peak pressures for underwater applications are typically expressed in dB referenced to 1 microPascal (μPa).

Another measure of the pressure waveform that can be used to describe the pulse is the sound energy itself. The total sound energy in the pulse is referred to in many ways, including the “total energy flux” (Finneran et al. 2005). Total energy flux is equivalent to the unweighted sound exposure level (SEL) for a plane wave propagating in a free field, a common unit of sound energy used in airborne acoustics to describe short-duration events. The unit for SEL is dB referenced to 1 μPa^2-sec. The total sound energy in an impulse accumulates over the duration of that pulse. How rapidly the energy accumulates may be significant in assessing the potential effects of impulses on fish.

Vibratory pile drivers also produce high-intensity noise, but work on a different principle and have a very different sound profile than discussed above. A vibratory driver works by inducing particle motion to the substrate immediately below and around the pile, causing liquefaction, allowing the pile to sink downward. For this reason, vibratory pile driving is only suitable where soft substrates are present. The noise produced during vibratory driving is lower in intensity, and can be considered continuous in comparison to the pulse-type noise produced during impact pile driving. Peak noise levels from vibratory driving are typically 10 to 20 dB lower than impact driving for a particular pile type (Caltrans 2009).

Applicable Noise Criteria for Fish. On July 8, 2008, the Fisheries Hydroacoustic Working Group (FHWG), whose members include NMFS' Southwest and Northwest Divisions; California, Washington, and Oregon departments of transportation; the DFW; and the U.S. Federal Highway Administration issued an agreement for the establishment of interim threshold criteria to determine the effects of high-intensity sound on fish. While these criteria are not formal regulatory standards, they are generally accepted as viable criteria for underwater noise effects on fish. These criteria were established after extensive review of analysis of the effect of underwater noise on fish. The agreed-upon threshold criteria for impulse-type noise to harm fish have been set at 206 dB peak, 187 dB accumulated SEL for fish over 2 grams, and 183 dB for fish less than 2 grams (Table 8Table 8).

Table 8.
FHWG Underwater Noise Thresholds for Fish

Impulse and Continuous Sound	Peak Noise (dB)	Accumulated Noise (SEL) (dB)
Fish under two grams in weight	>206	>183
Fish over two grams in weight	>206	>187

Source: (FHWG 2008)

Notes:

dB = decibel

SEL = sound exposure level

The FHWG has determined that noise at or above the 206-dB peak level can cause barotrauma to auditory tissues, the swim bladder, or other sensitive organs. Noise levels above the accumulated SEL may cause temporary hearing-threshold shifts in fish. Behavioral effects are not covered under these criteria but could occur at these levels or lower. Behavioral effects may include fleeing and the temporary cessation of feeding behaviors. A specific criterion has not yet been set by the FHWG for continuous noise, such as vibratory driving, so the same criteria as impulse-type noise would be used for this analysis. Juvenile spring-run Chinook salmon emigrate downstream as smolts between the sizes of 80 to 150 millimeter fork length, when they weigh approximately 6 to greater than 14 grams (MacFarlane and Norton 2002, Moyle 2002). Therefore, for the purposes of this analysis, a 206-dB peak level and 187-dB SEL are used as thresholds for potential harm to listed fish species.

Effects to Salmonids during Sheet Pile Installation. Sheet piles may be installed into the alluvium of San Joaquin River to create temporary cofferdams needed for the flow diversion systems or to reinforce levees. When possible, sheet piles would be installed using a vibratory hammer because NMFS considers this method to be less harmful to fish than pile driving with an impact hammer. However, certain scenarios may require the use of impact pile driving. The sound generated from either method is not expected to reach levels that would harm or injure fish. Some of the sheet piles would be placed and driven outside of the wetted channel which would attenuate sound transmission more rapidly. Even when sheet piles are driven into shallow water depths, the level of sound is quickly attenuated. In order to assess and minimize the impacts of underwater noise on salmonids, a pile driving analysis, including an assessment of sound levels from Project activities, would be submitted to NMFS 90 days prior to the start of any pile driving activities. NMFS would have 45 days to review the pile driving analysis so contractors can be given time to make necessary changes, if any, to follow NMFS guidance or criteria while staying on construction schedule.

Calculation of Potential for Injury or Mortality During Construction

Central Valley Steelhead. No spawning population of Central Valley steelhead currently exists in the San Joaquin River, therefore a rough estimate of the potential incidental take resulting from construction was calculated using data from non-hatchery origin adult and hatchery-origin juvenile Central Valley steelhead from the Mokelumne River system (see Section 3.3.1). This calculation estimated that 17 migrating adult steelhead, four emigrating adult steelhead (kelts), and 17,127 emigrating juveniles could move through Reach 2B annually, following full connectivity of the San Joaquin River from Sac Dam to Reach 1A and recovery of the a steelhead run in the San Joaquin River, and be impacted by Project construction. The estimate assumes that adult steelhead would be able to bypass current downstream barriers (e.g., Sack Dam and Mendota Dam) and successfully spawn in Reach 1A, that in-water work would occur year-round, and that 100 percent of fish that come into contact with construction activities would be incidentally taken. However, with the implementation of a fish rescue and relocation plan and the avoidance and minimization measures described in Section 2.2.28, Table 4, construction effects to Central Valley steelhead would be largely eliminated. Actual incidental take numbers during Project construction are not expected to exceed one juvenile, one spawning adult, and one kelt Central Valley steelhead per year and this incidental take would most likely be in the form of harassment to a fish that is trapped in a cofferdam, rescued, and relocated to suitable habitat.

Central Valley spring-run Chinook salmon. No spawning population of Central Valley spring-run Chinook salmon currently exists in the San Joaquin River. Therefore the 5-year running average target of a minimum of 2,500 naturally produced adult spring-run Chinook salmon and the minimum annual production target of 44,000 juveniles from the 2010 Fisheries Management Plan was used to estimate the number of adults and juveniles that could move through Reach 2B annually and be impacted by Project construction (SJRRP 2010b). This estimate assumes that adults returning to the San Joaquin River would bypass the trapping efforts at the Hills Ferry Barrier, Sack Dam, and Mendota Dam to migrate through Reach 2B, that in-water work would occur year-round, and that 100 percent of fish that come into contact with construction activities would be injured or killed. However, with the implementation of a fish rescue and relocation plan and the avoidance and minimization measures described in Section 2.2.28, Table 4, construction impacts to Central Valley spring-run Chinook salmon would be largely eliminated. Actual injury or mortality numbers during Project construction are not expected to exceed one juvenile and one adult Central Valley spring-run Chinook salmon per year, which most likely would occur in the form of harassment to a fish that is trapped in a cofferdam, rescued, and relocated to suitable habitat.

Effects to Critical Habitat

The Action Area does not overlap with designated critical habitat for Central Valley steelhead or Central Valley spring-run Chinook salmon and therefore the Project would have ***no effects*** to designated critical habitat for these species.

4.1.2 Potential Effects During Operation

Salmonid Entrainment in Mendota Pool

Once the Project is constructed, there are two scenarios in which water from the San Joaquin River would enter Mendota Pool. The first is when flood flows are released from Friant Dam, which occurs to improve the storage potential of Millerton Lake to retain floods or because Millerton Lake is spilling water. During flood flows, water that is diverted into Mendota Pool could be used by Exchange Contractors, similar to how flood flows routed to Mendota Pool are sometimes used now. The second scenario in which water from the San Joaquin River enters Mendota Pool occurs when water is released from Friant Dam for the purpose of supplying water to the Exchange Contractors. Potential entrainment of salmonids in Mendota Pool may occur during either of these two scenarios; however, Reclamation is not required to consider the effects of entrainment of salmonids during typical water deliveries in the incidental take analysis because this is a non-discretionary action controlled by the Exchange Contractors (see Section 4.2, Cumulative Effects).

Although Central Valley steelhead and Central Valley spring-run Chinook salmon may be entrained in Mendota Pool, it is possible during certain flood flow scenarios for salmonids entrained in Mendota Pool to escape by spilling over Mendota Dam. Flood flows from the San Joaquin River are occasionally accompanied by flood releases from the Kings River, which reach Mendota Pool through the Fresno Slough on average once every 4 years in the spring and early summer months. Exchange Contractors divert water from the San Joaquin River flood flows, but cannot divert water from Fresno Slough. Therefore, flood flows from the San Joaquin River enter canals while flood releases entering Mendota Pool via Fresno Slough spill over Mendota Dam, providing salmonids entrained in Mendota Pool an avenue for escape. The ability of entrained salmonids to escape Mendota Pool by spilling over Mendota Dam is dependent on the amount of flow originating from Fresno Slough.

Most salmonids entrained in Mendota Pool would likely experience a migration delay, but escape over Mendota Dam or under or between flashboards would be possible. However, some salmonids entrained in Mendota Dam could be killed by entering the canals. This possibility would be further discussed in Chapter 5 (Cumulative Effects) because Reclamation is not responsible for entrainment that may occur as a result of diversion from Mendota Pool into irrigation canals owned and operated by others.

Estimate of Central Valley Steelhead Incidental Take by Mendota Pool Entrainment. The *Mendota Pool Entrainment: Fish Screen Analysis* report estimated the percent of fall-run and spring-run Chinook salmon emigrating from Reach 2B that would be entrained in Mendota Pool (SJRRP 2015d). Reclamation updated the analysis to include Central Valley steelhead entrainment in an unpublished December 30, 2015 revision. The analysis used a daily flow model combining historical hydrology with future river conditions and future SJRRP Flows. The fractional volume of flow into Mendota Pool during each month was compared with juvenile Central Valley steelhead emigration patterns to estimate the average annual percentage of entrainment for each water year type (Table 11~~Table 9~~). The estimate of annual percent entrainment included entrainment due to flood control flows alone, as well as entrainment due to Exchange Contractor deliveries and flood control flows combined. The entrainment numbers are identical except for during the single critical low water year, where Exchange Contractor diversions were predicted to cause 49.3 percent entrainment and flood control flows were predicted to cause 0.0 percent entrainment. Because of the high level of entrainment during critical low water years due to Exchange Contractor deliveries and the fact that Reclamation is not responsible for incidental take during Exchange Contractor deliveries, the operational impacts calculation for Central Valley steelhead includes entrainment during flood control flows alone.

No spawning population of Central Valley steelhead currently exists in the San Joaquin River, therefore the potential incidental take resulting from entrainment in Mendota Pool was calculated using data from juvenile Central Valley steelhead from the Mokelumne River system (see Section 3.3.1). This calculation estimated that 233 emigrating juveniles could move through Reach 2B annually. For the purpose of estimating annual juvenile Central Valley steelhead entrainment in Mendota Pool, it is assumed that the calculations of steelhead abundance in Section 3.3.1 are reasonable (see Section 3.3.1 for calculation assumptions), that the percentage of flow diverted into Mendota Pool is proportional to the fraction of fish diverted to the pool, and that one hundred percent of emigrating juvenile Central Valley steelhead would travel through Reach 2B. Based on these assumptions, the average annual entrainment of juvenile steelhead is presented in Table 11~~Table 9~~. The lowest level of entrainment due to flood control flows alone would occur during critical low water years and the highest level of entrainment due to flood control flows alone would occur during normal wet water years.

Table 9.
Juvenile Central Valley Steelhead Entrainment by Water Year Type

Water Year Type	Number of Years in Model Run	Average Percent of Annual Juvenile Central Valley Steelhead Population Entrained Due to Flood Control and Exchange Contractor Flows	Average Percent of Annual Juvenile Central Valley Steelhead Population Entrained Due to Flood Control Flows Only	Average Number of Juvenile Central Valley Steelhead Entrained Annually Due to Flood Control Flows
Wet	16	3.5%	3.5%	9
Normal–Wet	24	6.5%	6.5%	16
Normal–Dry	25	1.3%	1.3%	4
Dry	12	0.7%	0.7%	2
Critical–High	4	1.7%	1.7%	4
Critical–Low	1	49.3%	0.0%	0

The percentile fraction of juvenile Central Valley steelhead annual entrainment by month is included in Table 12~~Table 10~~ and illustrates both the frequency at which entrainment may occur and the maximum potential annual entrainment. During 4 out of every 5 years (80 percent of years) there would be no entrainment of juvenile Central Valley steelhead in Mendota Pool. In 1 out of every 5 years (80th percentile) there would be 5 percent entrainment of juvenile Central Valley steelhead into Mendota Pool. The maximum potential entrainment of 21 percent would occur once every 20 years (95th percentile). Based on the analysis from the unpublished revision of the *Mendota Pool Entrainment: Fish Screen Analysis* report (predicting a maximum of 21 percent entrainment) and the estimate of Central Valley steelhead abundance in the San Joaquin River discussed in Section 3.3.1 (predicting 233 juveniles), the maximum entrainment of juvenile Central Valley steelhead into Mendota Pool would be 45 fish.

Table 10.
Percentiles of Fraction of Juvenile Steelhead Entrained at Mendota Pool by Month due to Flood Control Flows Only

Month	50th Percentile	60th Percentile	70th Percentile	80th Percentile	90th Percentile	95th Percentile
Oct	0%	0%	0%	0%	0%	0%
Nov	0%	0%	0%	0%	0%	0%
Dec	0%	0%	0%	0%	0%	0%
Jan	0%	0%	0%	0%	0%	0%
Feb	0%	0%	0%	0%	1%	1%
Mar	0%	0%	0%	2%	4%	5%
Apr	0%	0%	0%	0%	0%	0%
May	0%	0%	0%	0%	0%	<1%
Jun	0%	0%	0%	0%	8%	14%
July	0%	0%	0%	0%	0%	0%
Aug	0%	0%	0%	0%	0%	0%
Sep	0%	0%	0%	0%	0%	0%
TOTAL	**0%**	**0%**	**0%**	5%	8%	19%

The unpublished revision of the *Mendota Pool Entrainment: Fish Screen Analysis* report did not include an estimate of Central Valley steelhead kelt entrainment in Mendota Pool. Therefore, it is assumed that kelt entrainment into Mendota Pool will be 10.66 percent, the percent of total annual flow predicted to enter Mendota Pool (SJRRP 2015d). The estimate of Central Valley steelhead abundance in the San Joaquin River discussed in Section 3.3.1 predicts 4 emigrating kelts annually. Based on these estimates, there would be 0.43 kelts entrained in Mendota Pool per year, which is rounded up to 1 fish annually. This is a conservative estimate of kelt entrainment because it assumes that kelts could be present at any time during the year and does not take kelt emigration timing into account.

Estimate of Central Valley Spring-Run Chinook Salmon Entrained in Mendota Pool. The *Mendota Pool Entrainment: Fish Screen Analysis* report estimated the percent of Chinook salmon emigrating from Reach 2B that would be entrained in Mendota Pool (SJRRP 2015d). The analysis used a daily flow model combining historical hydrology with future river conditions and future SJRRP Flows. The fractional volume of flows into Mendota Pool during each month was compared with juvenile Chinook salmon emigration patterns to estimate the average annual percentage of entrainment for each water year type (Table 11~~Table 11~~) (SJRRP 2015d). This estimate of operational impacts includes entrainment due to both flood flows and Exchange Contractor diversions and is therefore a somewhat conservative estimate; however, Exchange Contractor diversions are expected to account for less than 2 percent of entrainment for spring-run Chinook.

The 2010 Fisheries Management Plan defines SJRRP population objectives, including a minimum annual production target of 44,000 spring-run Chinook salmon juveniles and a maximum annual production target of 1,575,000 juveniles (SJRRP 2010b). For the purpose of estimating annual Central Valley spring-run Chinook salmon entrainment in

Mendota Pool, it is assumed that at least the minimum annual production target would be met sometime during or after construction of the Project, that only juveniles would be entrained, that the percentage of flow diverted into Mendota Pool is proportional to the fraction of fish diverted to the pool, and that 100 percent of emigrating juvenile Central Valley spring-run Chinook salmon would travel through Reach 2B. Based on these assumptions, the average annual entrainment of juvenile Central Valley spring-run Chinook salmon is presented in Table 11~~Table 9~~. The lowest level of entrainment would occur during critical low water years and the highest level of entrainment would occur during wet water years.

Table 11.
Central Valley Spring-Run Chinook Entrainment by Water Year Type

Water Year Type	Number of Years in Model Run	Average Percent of Annual Juvenile Central Valley Spring–Run Chinook Salmon Population Entrained	Average Number of Juvenile Central Valley Spring-Run Chinook Salmon Entrained Annually
Wet	16	7.4%	3,256 – 116,550
Normal–Wet	24	6.7%	2,948 – 105,525
Normal–Dry	25	8.3%	3,652 – 130,725
Dry	12	5.1%	2,244 – 80,325
Critical–High	4	4.2%	1,848 – 66,150
Critical–Low	1	3.6%	1,584 – 56,700

The percentile fraction of spring-run Chinook salmon annual entrainment by month is included in Table 12~~Table 12~~ and illustrates both the frequency at which entrainment may occur and the maximum potential annual entrainment (SJRRP 2015d). During 4 out of every 5 years (80 percent of years) there would be no entrainment of Central Valley spring-run Chinook salmon in Mendota Pool. In 1 out of every 5 years (80^{th} percentile) there would be 17 percent entrainment of Central Valley spring-run Chinook salmon into Mendota Pool. The maximum potential entrainment of 32 percent would occur once every 20 years (95^{th} percentile). Based on the analysis from the *Mendota Pool Entrainment: Fish Screen Analysis* report (predicting a maximum of 32 percent entrainment) and the 2010 Fisheries Management Plan minimum and maximum annual production targets (44,000 to 1,575,000 juveniles), the maximum entrainment of juvenile Central Valley spring-run Chinook salmon into Mendota Pool would be 14,080 to 504,000 fish.

Table 12.
Percentiles of Fraction of Spring-Run Chinook Salmon Entrained at Mendota Pool by Month

Month	50th Percentile	60th Percentile	70th Percentile	80th Percentile	90th Percentile	95th Percentile
Oct	0%	0%	0%	0%	0%	0%
Nov	0%	0%	0%	0%	0%	0%
Dec	0%	0%	0%	0%	0%	0%
Jan	0%	0%	0%	0%	0%	0%
Feb	0%	0%	0%	13%	19%	20%
Mar	0%	0%	0%	4%	10%	11%
Apr	0%	0%	0%	0%	0%	0%
May	0%	0%	0%	0%	<1%	<1%
Jun	0%	0%	0%	0%	<1%	1%
July	0%	0%	0%	0%	0%	0%
Aug	0%	0%	0%	0%	0%	0%
Sep	0%	0%	0%	0%	0%	0%
TOTAL	**0%**	**0%**	**0%**	**17%**	**29%**	**32%**

Floodplain Stranding

Rearing juvenile salmonids could become stranded on the floodplain under certain conditions, resulting in possible mortality if the stranded areas desiccate or if the stranded fish are exposed to elevated temperatures or levels of predation. Most floodplain stranding occurs in manmade pits or behind structures like levees, berms, or weirs that impede drainage (Moyle et al. 2007). However, the risk of salmonid stranding on floodplains appears to be relatively low even when manmade structures are present on the floodplain; a study of spring-run Chinook in the Yolo Bypass found that, despite natural and manmade structures potentially creating stranding pools, the majority of fish survived and successfully emigrated off the floodplain (Sommer et al. 2005). Stranding of all fishes is reduced on floodplains with well-drained topography with channels that allow flows to drain back to the river unimpeded (Moyle et al. 2007, Sommer et al. 2005).

Floodplain habitat is valuable to rearing salmonids as it allows for high invertebrate production and increased salmonid foraging opportunity, lower water velocities allowing for less energy expenditure, and possibly reduced predation due to abundant refuge habitat (Sommer et al. 2005). Several studies have demonstrated a positive relationship between floodplain rearing and juvenile Chinook salmon growth (Sommer et al. 2001, Sommer et al. 2005, Jeffres et al. 2008). The value of floodplain habitat as rearing and food production habitat, which results in larger juveniles that are more likely to successfully survive and spawn, offsets the risk of juvenile mortality due to stranding (Sommer et al. 2005).

The risk of floodplain stranding would be minimized as described in the Rearing Habitat Design Objectives. Strategies to achieve Objective 7, managing unnatural stranding, include removal of existing roads, levees, and other blockages in the floodplain; filling in, permanent isolation, or flow connection through borrow areas and gravel pits; floodplain grading that generally grades toward the river when possible; and creating side channels and high flow channels to minimize grading and stranding. Floodplain grading would help ensure that low-lying floodplain areas are connected to the river and that escape routes are graded to prevent stranding during receding flows. In addition, monitoring efforts would continue after the Compact Bypass is opened in order to identify any potential stranding issues and, should such issues arise, adaptive management would be used to minimize stranding. Due to the low risk of floodplain stranding of salmonids, the comparative benefit of floodplain habitat for rearing, and the measures that would be taken to avoid stranding, the adverse impact of floodplain stranding to Central Valley steelhead and Central Valley spring-run Chinook salmon would be discountable.

Pollutants

The Project would allow for agricultural use on the expanded floodplains within the levees. These activities would likely occur during periods when the floodplain is dry. Agricultural practices (e.g., annual crops, pasture, floodplain-compatible permanent crops) could occur on the floodplain in previous agricultural areas outside of State-owned and public trust lands. Growers would be required to leave cover on the ground and would be required to develop and implement a Water Quality Plan, approved by Reclamation, to meet then-existing water quality standards for coldwater fisheries beneficial uses in downstream areas. If grazing occurs the lessee would be required to develop and implement a Grazing Plan, approved by Reclamation, in addition to the Water Quality Plan. It is assumed that agricultural activities would not occur within 300 feet of the active channel and would also not occur on any constructed floodplain benches adjacent to the main channel or on secondary channels. The levee setbacks would allow inundation of 1,530 acres of floodplain at 4,500 cfs, the maximum channel capacity. Agricultural activity would be allowed on the floodplain within the proposed levee alignment outside riparian habitat restoration areas on up to 890 acres.

While flooding of a native floodplain may improve rearing habitat for outmigrating juvenile salmonids, agricultural activities would result in periodic soil disturbance, deposition of animal waste, fertilizer, or pesticide applications associated with planting of grasses, and annual crops or floodplain-compatible crops on the floodplain. The use of fertilizers and pesticides could introduce contaminants directly to the floodplain where they could potentially become entrained in the flow and affect juvenile salmonids rearing in Reach 2B or in downstream reaches. While agriculture may introduce contaminants to the floodplain and river, there is experimental evidence from the Yolo Bypass that rearing juvenile Chinook salmon on an agricultural floodplain consisting of rice fields can have high growth rates (Katz et al. 2013). San Joaquin River and Reach 2B are not expected to support rice fields, however this study suggests that agriculture on floodplains may still serve as beneficial rearing habitat for juvenile salmonids. The potential adverse impacts of agriculture would occur intermittently throughout the agricultural uses and would be mitigated through the implementation of a Water Quality Plan and a Grazing Plan.

Operation and Maintenance

There is a small possibility that long-term operation and maintenance of Reach 2B would adversely affect Central Valley steelhead or Central Valley spring-run Chinook salmon.

Operation and maintenance activities (e.g., levee restoration, periodic floodplain and channel shaping, clearing of San Mateo Avenue culvert, and in-channel sediment removal in the vicinity of the control structures, the fish passage facility, and the fish barrier) are described in more detail in Section 2.2.20 (Operations and Maintenance). Such activities may injure or kill salmonids in Reach 2B or adversely affect habitat. These effects are expected to be minimal due to the infrequency of in-water operation and management activities. BMPs would be used to minimize any potential adverse effect due to operation and maintenance of Reach 2B.

4.1.3 Summary of Construction and Operation Impacts

The following table summarizes the estimated number of Central Valley steelhead and Central Valley spring-run Chinook salmon that may be adversely affected by Project construction and operation (Table 13~~Table 13~~).

Table 13.
Summary of Annual Estimated Fish Adversely Affected During Construction and Operation

	Annual Construction Impacts	Annual Operation Impacts
Central Valley steelhead (juvenile)	1	45
Central Valley steelhead (adult)	1	-
Central Valley steelhead (kelt)	1	1
spring-run Chinook salmon (juvenile)	1	14,080 - 504,000
spring-run Chinook salmon (adult)	1	-

4.1.4 Beneficial Effects

The Project would have a beneficial effect to Central Valley steelhead and Central Valley spring-run Chinook salmon by increasing floodplain habitat and improving the aquatic food web in Reach 2B, facilitating upstream and downstream fish passage, improving river connectivity, and providing rearing habitat for juvenile salmonids. These beneficial effects would far outweigh the adverse effects of Project construction and operation for salmonids and other native fishes.

Salmonid Rearing Habitat

The Project would provide a new levee system that would create a 4,200-foot average-width floodplain through Reach 2B that would support food production and rearing habitat. The levee setbacks would allow inundation of 1,000 acres of floodplain at 2,500 cfs. This magnitude of flow would create approximately 440 acres of shallow water habitat (less than 1 foot deep) for primary production and approximately 560 acres of deeper habitat that could directly support rearing conditions. Floodplain areas adjacent to the main channel would start inundating between 1,200 and 2,200 cfs and would encourage riparian regeneration. In addition, active riparian and floodplain habitat restoration would occur along both banks of the low flow channel of the river up to 450 feet from the bank. In accordance with the Rearing Habitat Design Objectives, active floodplain restoration would include native species that would provide shade and reduce air temperatures to help minimize water temperatures, provide large woody debris and organic matter needed to provide salmonid habitat and food, and help stabilize the low-flow channel.

The draft Hydraulic and Revegetation Design of the Mendota Bypass – 30% Design (Appendix A) provides a detailed description of the revegetation efforts for the Compact Bypass area. High density riparian areas (defined as those areas in the range of 0 to 2 feet above summer base flow elevations) would be heavy planted with woody shrubs and trees. There would be 22 acres of this type of revegetation effort in the bypass channel. Mid-density riparian areas (elevation of 2 to 8 feet above summer base flow) include patches of open herbaceous, clusters of shrubs, tree groves, and intermixed areas. There would be 33 acres of this type of revegetation effort in the bypass channel. The high density and mid-density riparian revegetation areas would not be used for agriculture. Upland areas (greater than 8 feet above summer baseflow) would be seeded with forbs and grasses to stabilize soils and reduce invasive species colonization. There are about 72 acres of this type of revegetation in the bypass channel. Upland areas that were previously used for agriculture may be used for agriculture in the future if farmers lease the land from Reclamation and develop and implement a Water Quality and/or Grazing Plan, as appropriate. Although the revegetation is not yet designed for the Reach 2B floodplain area, the design concepts are expected to be similar. Section 2.2.5 contains further details about active floodplain restoration, including a table of species that are likely to be planted or seeded (Table 2).

Upstream Migration of Adult Salmonids

The Project would provide upstream passage from Reach 3 through Reach 2B and into Reach 2A. The Compact Bypass would be constructed with two grade control steps to facilitate upstream passage. A fish passage facility would provide up and downstream fish passage between the Compact Bypass and the river upstream of the Compact Bypass Control Structure during times when operation of the control structure impedes passage. The San Mateo Avenue crossing would be removed. The Chowchilla Bifurcation Structure would have a fish passage facility to provide passage when operation impedes passage through the structure. There would be up to 41 hydraulic steps that fish would have to pass over and four river-spanning structures between Reach 3 and Reach 2A (two Compact Bypass grade control structures, Compact Bypass Control Structure and passage facility, and the Chowchilla Bifurcation Structure and passage facility). If control structures are being operated for fish passage, which would occur most of the time, then the number of hydraulic steps between Reach 3 and Reach 2A would be reduced to as few as four. Diversions would be screened or isolated in Mendota Pool, which would minimize false migration pathways. These measures would ensure that upstream migration of adult salmonids would be greatly improved as a result of the Project.

Downstream Migration of Juvenile Salmonids

The Project would improve downstream passage by screening water diversions, isolating operations of Mendota Pool from the river, and providing improved downstream passage for juvenile salmon. Mendota Pool would only be operated for Exchange Contractor diversions in summer months in highly infrequent dry years or during flood flow deliveries, when flows split several times before entering Mendota Pool and fish survival through the bypasses is high. Downstream fish passage would be improved at the

Chowchilla Bifurcation Structure by installation of a fish passage facility on the San Joaquin River Control Structure. A fish passage facility at the Compact Bypass Control Structure would allow fish to migrate around when operations impede downstream passage. The San Mateo Avenue crossing would be removed. These measures ensure that downstream migration of juvenile salmonids would be greatly improved as a result of the Project.

Aquatic Food Web

The Project would provide improved food-web conditions through increased capacity and expanded floodplains. Levees would be set back and floodplain areas would be expanded, making it possible to inundate the majority of the floodplain about every other year through Restoration Flows up to 4,500 cfs, which would potentially create conditions for improved primary and secondary production that would otherwise not occur. The increased floodplain area, increased frequency of inundation, and the wider floodplains combined with Restoration Flows would have a beneficial effect on the aquatic food web in Reach 2B.

4.2 Cumulative Effects

Cumulative effects as defined by the ESA are those effects of future State or private activities that are reasonably certain to occur within the Action Area (ESA, Section 402.14[g][4]). The Project in combination with other non-federal Projects in the area could contribute to adverse effects on Central Valley steelhead or Central Valley spring-run Chinook salmon in the local area as a result of the temporary loss of habitat and adverse effects on habitat (e.g., erosion, sedimentation, increases in turbidity and temperature, decreases in DO, and introduction of pollutants) in Reach 2B. However, the long-term effects of the project and implementation of the SJRRP would be beneficial due to creation of floodplain habitats and implementation of Restoration flows.

None of the cumulative State and private projects or plans referenced in the PEIS/R would likely adversely affect fisheries conditions in the Action Area based on their location relative to the Project and their intention to improve aquatic habitat conditions (SJRRP 2011b, pages 26-3 to 26-33). Many programs occur downstream within the Bay-Delta, while others occur elsewhere in the Central Valley (e.g., Sacramento River basin).

Construction activity in the active channel could result in small, incremental adverse effects on aquatic species, including crushing, disturbance of organisms, release of sediment, and release of pollutants associated with ground disturbance or equipment operation. These effects would be minimized by the use of cofferdams installed during low flow conditions and fish removal from the construction areas prior to installation. Water from dewatered construction sites would be placed in settling basins or treated prior to release into the river or Mendota Pool. No other notable cumulative projects would contribute to this incremental effect.

As discussed in Section 4.1.2, there is potential for Central Valley steelhead or Central Valley spring-run Chinook salmon to be entrained in Mendota Pool during flood flows or during Exchange Contractor water deliveries. Most entrained salmonids would experience a migration delay, but would have some opportunity for escape. However, some salmonids entrained in Mendota Pool could enter canals during water diversions from Mendota Pool, almost certainly resulting in mortality. While Reclamation is not responsible for entrainment in the irrigation canals, which are owned and operated by others, salmonid entrainment and mortality in the canals would not be possible in the absence of the Project because, without the Project, there would be no listed fish present in Mendota Pool.

Based on the information presented above, there could be a cumulative effect of Exchange Contractor water deliveries on Central Valley steelhead or Central Valley spring-run Chinook salmon as these water deliveries from Mendota Pool have the potential to entrain and kill listed salmonids.

4.3 Conclusions

The Conservation Strategy in Section 2.2.28, Table 4 outlines conservation measures included in the proposed action to avoid and minimize potential effects to Central Valley steelhead and Central Valley spring-run Chinook salmon.

4.3.1 Summary of Effects to Central Valley Steelhead

The Project would involve building levees, restoring floodplain habitat, constructing a channel and structures capable of conveying water around and to Mendota Pool, and providing upstream and downstream fish passage in Reach 2B. Project construction activities have the potential to injure or kill Central Valley steelhead, degrade habitat quality (via sedimentation, increases in turbidity and temperature, and introduction of pollutants), and produce harmful levels of noise during construction. In addition, adverse effects during Project operation may include entrainment in Mendota Pool, stranding on the floodplain, exposure to agricultural pollutants, possible injury or mortality during maintenance activities, and cumulative effect of Exchange Contractor water deliveries. Conservation Measures WUS-1, WUS-2, CVS-1, CVS-2, EFH-1, and EFH-2 would be implemented to avoid and minimize habitat effects and the risk of incidental take associated with construction and operation activities. However, because the Conservation Measures cannot completely eliminate the possibility of the Project impacting Central Valley steelhead, Reclamation has determined in coordination with NMFS and in accordance with Section 7(a)(2) of the ESA, the Project ***may affect, and is likely to adversely affect*** Central Valley steelhead. Despite the minimal potential adverse impacts to Central Valley steelhead, the Project is expected to provide valuable salmonid rearing habitat, facilitate upstream and downstream migration, and result in a more diverse aquatic food web that would improve conditions for salmonids and may result in an expansion of the current range of Central Valley steelhead.

The action area does not overlap with designated critical habitat for Central Valley steelhead. Therefore, the Project would have ***no effect*** on Central Valley steelhead designated critical habitat.

4.3.2 Summary of Effects to Central Valley Spring-Run Chinook Salmon

The Project would involve building levees, restoring floodplain habitat, constructing a channel and structures capable of conveying water around and to Mendota Pool, and providing upstream and downstream fish passage in Reach 2B. Project construction activities have the potential to injure or kill Central Valley spring-run Chinook salmon, degrade habitat quality (via sedimentation, increases in turbidity and temperature, and introduction of pollutants), and produce harmful levels of noise during construction. In addition, adverse effects during Project operation may include entrainment in Mendota Pool, stranding on the floodplain, exposure to agricultural pollutants, possible injury or mortality during maintenance activities, and cumulative effect of Exchange Contractor water deliveries. Conservation Measures WUS-1, WUS-2, CVS-1, CVS-2, EFH-1, and EFH-2 would be implemented to avoid and minimize habitat effects and the risk of injury and mortality associated with construction and operation activities. However because the Conservation Measures cannot completely eliminate the possibility of the Project impacting Central Valley spring-run Chinook salmon, Reclamation has determined in coordination with NMFS and in accordance with Section 7(a)(4) of the ESA, the Project ***may affect, but would not jeopardize*** the non-essential experimental population of Central Valley spring-run Chinook salmon within the San Joaquin River. Despite the minimal potential adverse impacts to Central Valley spring-run Chinook salmon, the Project is expected to provide valuable salmonid rearing habitat, facilitate upstream and downstream migration, and result in a more diverse aquatic food web that would improve conditions for salmonids and may result in an expansion of the current range of Central Valley spring-run Chinook salmon. Therefore, Reclamation is requesting an informal conferencing opinion from NMFS on Central Valley spring-run Chinook salmon.

The action area does not overlap with designated critical habitat for Central Valley spring-run Chinook salmon. Therefore, the Project would have ***no effect*** on Central Valley spring-run Chinook salmon designated critical habitat.

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5.0 Magnuson-Stevens Fishery Conservation and Management Act

5.1 Essential Fish Habitat

There are four FMPs in the Pacific region under the MSFCMA (Pacific salmon, groundfish, coastal pelagic species, and highly migratory species), but only Pacific Salmon EFH occurs within the boundaries of the Action Area. EFH for Chinook salmon (*Oncorhynchus tshawytscha*) has been designated in the Sacramento and San Joaquin River basins under the Pacific Coast Salmon FMP and includes the Action Area. Chinook salmon stocks with potential to occur in Reach 2B include Central Valley fall-run and late fall-run Chinook salmon. However the Action Area and Reach 2B are nearly completely separated from the lower San Joaquin River and the ocean fishery by a lack of connectivity and several fish barriers.

The Habitat Area of Particular Concern (HAPC) established under the Pacific Coast Salmon FMP consist of complex channels and floodplain habitats; thermal refugia; spawning habitat; estuaries; and marine and estuarine submerged aquatic vegetation. Most of Reach 2B currently contains low quality habitat for salmonids because it lacks channel complexity, thermal refugia, and suitable gravel and cobble spawning habitat. Therefore, there are no areas within Reach 2B that contain HAPC under the Pacific Coast Salmon FMP.

5.2 Effects to Essential Fish Habitat

The Project goals include restoring floodplain habitat and providing upstream and downstream fish passage for the benefit of juvenile and adult salmonids and other native fishes. Overall the Project would benefit EFH by improving habitat and connectivity. However, Project construction activities may adversely affect Pacific Salmon EFH, including habitat for fall-run and late fall-run Chinook salmon. During construction the Project may cause a temporary loss of Pacific Salmon EFH, erosion and sedimentation, local increases in turbidity, change in temperature, and introduction of pollutants into the San Joaquin River. The causes and implications of these impacts for Pacific Salmon EFH would be similar to those discussed for Central Valley steelhead and Central Valley spring-run Chinook salmon (Section 4.1). All of the potential adverse impacts would be temporary in nature, with the exception of agricultural activity on the expanded floodplain, and would result from construction, materials storage, staging, and access during implementation of the Project. None of the Project effects to EFH are expected to negatively affect Chinook salmon populations, due to their status in the Action Area, and over the long-term the Project should benefit Chinook salmon populations.

5.3 Avoidance and Minimization Measures for Essential Fish Habitat

The Conservation Strategy in Section 2.2.28, Table 4 outlines conservation measures for biological resources that may be affected by Project actions and includes avoidance, minimization, and mitigation measures. The Conservation Strategy, and specifically Conservation Measures WUS-1, WUS-2, CVS-1, CVS-2, EFH-1, and EFH-2, would be implemented as part of the Project to minimize potential adverse effects of Project activities on Pacific Salmon EFH.

5.3.1 Summary of Effects to Essential Fish Habitat

The Project goals include restoring floodplain habitat and providing upstream and downstream fish passage for the benefit of juvenile and adult salmonids and other native fishes. The Project would involve building levees, restoring floodplain habitat, constructing a channel and structures capable of conveying water around and to Mendota Pool, and providing upstream and downstream fish passage in Reach 2B. Project construction activities have the potential to temporarily degrade Pacific Salmon EFH through sedimentation, increases in turbidity, changes in water temperature, and introduction of pollutants. Therefore, the Project ***may adversely affect*** Pacific Salmon EFH. However, in the long term, the Project would benefit EFH by improving habitat and connectivity.

6.0 References

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